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MEMOIRS

OF THE

AMERICAN MUSEUM OF NATURAL HISTORY.

NEW SERIES, VOLUME II, PART I.

EQUIDÆ OF THE OLIGOCENE, MIOCENE, AND PLIOCENE OF NORTH AMERICA, ICONOGRAPHIC TYPE REVISION.

BY HENRY FAIRFIELD OSBORN.

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BY HENRY FAIRFIELD OSBORN.

HONORARY CURATOR OF VERTEBRATE PALÆONTOLOGY IN THE AMERICAN MUSEUM OF NATURAL HISTORY, VERTEBRATE PALÆONTOLOGIST U. S. GEOLOGICAL SURVEY.

PLATES 1–54, AND 173 TEXT FIGURES.

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PREFACE AND ACKNOWLEDGMENTS.

The systematic revision of the fossil horses of North and Central America has been in progress under the direction of the author since the year 1900 in preparation for his "Monograph of the Equidæ." The work in the American Museum of Natural History has been carried on with the coöperation of James Williams Gidley, Walter Granger, and William Diller Matthew. Recently Oliver Perry Hay of the Carnegie Institution, Washington, has continued the revision of the Pleistocene species of *Equus* which was begun by Gidley. John Campbell Merriam of the University of California through his explorations has added an important series of Miocene and Pliocene species from the central desert and Pacific coast regions. The author's acknowledgments are due also to the writings of Earl Douglass, O. A. Peterson, Erwin H. Barbour, Richard Swann Lull, Edward L. Troxell, and E. H. Sellards.

Systematic Revisions.— The published and manuscript revisions by the American Museum as completed or in progress are chiefly as follows:

Titles	*Reference in Text*
Gidley, J. W.	
"Tooth Characters and Revision of the North American Species of the Genus Equus," *Bull. Amer. Mus. Nat. Hist.*, Vol. XIV, Art. IX, May 31, 1901, pp. 91–142, plls. XVIII–XXI, 27 text figs.	(Gidley, 1901)
"Proper Generic Names of Miocene Horses," *Bull. Amer. Mus. Nat. Hist.*, Vol. XX, Art. XV, May 28, 1904, pp. 191–194	(Gidley, 1904)
"Revision of the Miocene and Pliocene Equidæ of North America," *Bull. Amer. Mus. Nat. Hist.*, Vol. XXIII, Art. XXXV, Nov. 26, 1907, pp. 865–934	(Gidley, 1907)
Matthew, W. D., and Gidley, J. W.	
"New or Little Known Mammals from the Miocene of South Dakota, Part IV, Equidæ," J. W. G. *Bull. Amer. Mus. Nat. Hist.*, Vol. XXII, Art. VIII, May 26, 1906, pp. 135–154, 20 text figures	(Gidley, 1906)
Osborn, Henry Fairfield.	
"New Oligocene Horses," *Bull. Amer. Mus. Nat. Hist.*, Vol. XX, Art. XIII, May 28, 1904, pp. 167–179, pls. IV, V, 8 text figs.	(Osborn, 1904)
Granger, Walter.	
"A Revision of the American Eocene Horses, "*Bull. Amer. Mus. Nat. Hist.*, Vol. XXIV, Art. XV, Mar. 25, 1908, pp. 221–264, pls. XV–XVIII, 5 text figs.	(Granger, 1908)
Matthew, W. D.	
(MS.) During the year 1912–13 Dr. W. D. Matthew undertook the study of the Upper Oligocene, Miocene, and Pliocene Equidæ in the collections of the American Museum of Natural History, compiling also notes on the systematic revision of the types of new genera and species and on the phylogenetic or evolutionary relationships of the Miocene and Pliocene equines	(Matthew, 1913)

The author is chiefly indebted to the original researches by Matthew mentioned above (Matthew, 1913) on the Miocene and Pliocene species of Equidæ in the collections of the American Museum of Natural History. At first a joint report was contemplated; but for certain reasons it has appeared wiser that the present revision should appear under a single name. The author issues it, therefore, with the fullest acknowledgment of his indebtedness to his colleague, from whose descriptions, observations, and definitions many quotations are taken entire without amendment. On certain points of difference of interpretation and opinion which have arisen the author holds himself solely responsible.

In this revision the author has been aided constantly also by Professor J. C. Merriam, who has furnished a complete series of type illustrations, and in addition to his published works has contributed invaluable notes.

Professor R. S. Lull has contributed all the records which have been preserved regarding the type materials in the Marsh collection of the Peabody Museum, Yale University.

The manuscript has been prepared and the proofs corrected chiefly by Miss H. Ernestine Ripley.

Illustrations.— The present revision is *iconographic* in the sense that all the original type figures of authors are reproduced in *facsimile,* and all unfigured types, especially those of Marsh, are now figured for the first time, chiefly from the remarkable pencil drawings of the two Japanese artists Mr. S. Oka, who worked at the American Museum from Nov. 1, 1901, until April 30, 1903, and Mr. Binya Yoshihara, who worked from Feb. 1, 1904, until Jan. 31, 1907. It is a pleasure to acknowledge the skill and fidelity of these accomplished artists, whose drawings will be reproduced by lithography in the author's "Monograph of the Equidæ." The present memoir is illustrated also by fifty-four comparative plates executed in 1912, 1913, 1915, 1916, by Mrs. Lindsey Morris Sterling under the direction of the author and Dr. W. D. Matthew.

INTRODUCTION.

The permanent data of systematic palæontology are the *type specimen*, determinate or indeterminate, the *type locality*, the *type geologic level*. Descriptions, figures, opinions, inferences, phylogenetic and other speculations are subject always to the fallibility of human observation and interpretation.

Humanum est errare is a principle nowhere more repeatedly illustrated than in the literature on the fossil horses. Much excuse for human error is to be found, first, in the fragmentary character of many of the types, second, in the highly complex structure of the equine molar tooth, which is one of the most difficult objects to define and describe in the whole field of vertebrate palæontology because its specific characters and proportions differ at every age and plane, from the summit of the unworn crown to the region of the fangs at the base of the tooth. This fact, first clearly set forth by Gidley (1901, pp. 94–101), was little appreciated by Leidy, Cope, and Marsh, who together described sixty of the one hundred and forty-six recorded species of Oligocene-Pliocene Equidæ. The observations of Leidy especially were extremely accurate as well as philosophic; Cope's work while the most voluminous was the most confusing in respect to specific and generic determination and terminology; Marsh's descriptive work was accurate but had little regard for Leidy's priority in many instances.

The present review of the equine types is by no means final for the final revision and synonymy will depend upon monographic research of a nature which has not yet been attempted on this group. Nor has there been time in the present memoir to apply all the newer criteria of either *single character genesis and evolution* or *proportional character evolution* which have gradually become apparent through the observations of Osborn.

For historic reference, in the present revision the original author's description of each species is quoted direct, or in abstract with interpolation [ ] of modern odontological terms by Osborn. Thus "(Leidy, 1869)" signifies that Leidy's original language, definition or observations are quoted without comment, "(Leidy, 1869, Osborn, 1918)" signifies that Osborn interpolates [modern terms] in Leidy's description, "(Matthew, 1913, Osborn, 1918)" signifies that Osborn endorses or expands Matthew's definition.

I. PROPORTIONAL CHARACTER EVOLUTION.

1. *Head Ratios and Indices.*

1. Facio-cranial index = preorbital length × 100 ÷ basilar length.
2. Dental ratio = p^2–m^3 length × 100 ÷ basilar length.
3. Premolar-molar ratio = length p^{2-4} × 100 ÷ length m^{1-3}.
4. Molar hypsodont index = transverse breadth of crown near summit × 100 ÷ length of crown.

The above indices and ratios are among the most important.

1. In *Mesohippus* the cranium is typically longer than the face. In *Miohippus* and all higher stages the face becomes increasingly longer than the cranium.

2. The *dental ratio* gives the proportion between the entire length of the grinding series and the basilar length of the skull.

3. *Premolar-molar ratio:* the premolar series is shorter and the premolars are smaller in Eocene and early Oligocene horses; in late Oligocene horses the premolars progressively increase in size so that they are larger and occupy more linear space than the molars.

4. *Molar hypsodont index:* the length of the molar crown expressed in the molar hypsodont index is extremely important but often difficult to obtain. In Eocene and Oligocene horses the width of the crown exceeds the height. In all higher stages the height progressively exceeds the width.

2. *Limb Ratios and Indices.*

1. Metacarpo-brachial ratio = length of Mtc. III × 100 ÷ length of entire brachium (humerus, ulna-radius, manus).
2. Metatarso-crural ratio = Mts. III × 100 ÷ length of crus (femur, tibia-fibula, pes).
3. Radio-humeral ratio = length of radius × 100 ÷ length of humerus.
4. Tibio-femoral ratio = length of tibia × 100 ÷ length of femur.
5. Mtc. III index = least transverse diameter of shaft × 100 ÷ greatest length of shaft.

All the above ratios and indices express *adaptations to speed and weight* respectively, as brought out in the recent investigations of Osborn and Gregory. There are many other speed and weight adaptations in the skeleton; the above are the most frequently available and measurable.

3. *Digital and Phalangeal Reduction and Degeneration.*

1. *Tetradactyl, isotridactyl, anisotridactyl, monodactyl stages* in the reduction of the lateral and acceleration of the median digit, terminating in the monodactylism of *Pliohippus* and *Equus.*
2. *Stages in the reduction of the trapezium and of Mtc. V.*
3. *Pollex.* Digit I, absent in the known Equidæ. No trace of Mtc. I has been found in any of the known Eocene Equidæ or, in fact, other Eocene Perissodactyla. Search by Matthew among the remains of *Mesohippus, Parahippus, Merychippus, Pliohippus,* and *Hipparion* has failed to confirm previous observations of the presence of even a vestige of Mtc. I. The bone which previously was mistaken for this vestige is the trapezium, a carpal which often descends on the side of Mtc. II.
4. *Trapezium.* Though losing its function of supporting Mtc. I, the trapezium (Plate 39) persists in the Oligocene and Pliocene Equidæ, and occurs as a variable element in the Pleistocene and modern *Equus;* it often descends on the side of Mtc. II so as to imitate the vestige of Mtc. I.
5. *Displacement.* Proximal expansion of Mts. III. Matthew has observed the following articulations:

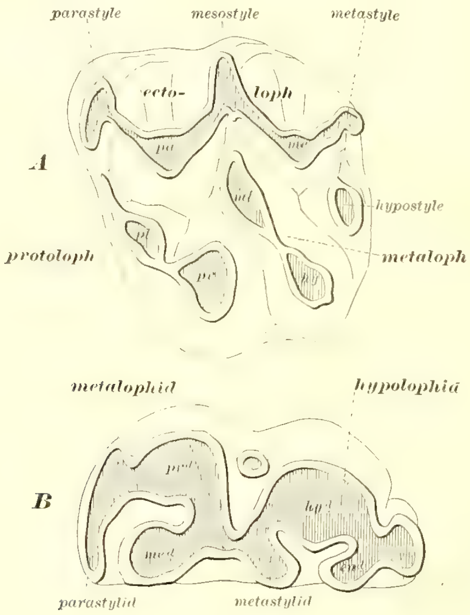


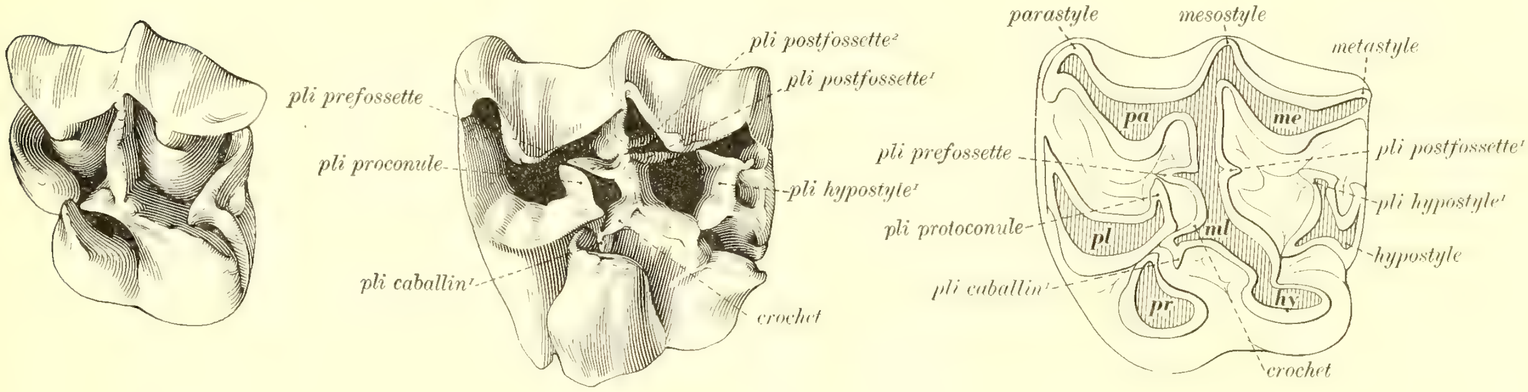
Fig. 1. Chief elements of the equine molar teeth.
A (Upper) Crown of buno-lopho-selenodont upper molars in an Oligocene stage of evolution.
B (Lower) Crown of the lower molar in a Pliocene stage of evolution.
After Osborn, 1907, fig. 160, p. 174.

Mts. III articulates with ectocuneiform only in all Lower and Middle Oligocene species, so far as known.	Mts. III articulates with ectocuneiform and cuboid in all Upper Oligocene species of *Mesohippus* and *Miohippus;* also in *Parahippus, Merychippus, Hipparion* (all American species except one), *Protohippus.*	Mts. III articulates with ectocuneiform, cuboid, and mesocuneiform, slightly in *Kalobatippus* and *?Archæohippus,* broadly in *Anchitherium, Hypohippus, Hipparion* (all Old World species), *Pliohippus, Hippidium, Onohippidium, Equus.*

II. Genesis and Evolution of Single Dental Characters.

The fundamental characters shown in the Lower Oligocene *Mesohippus* molar and succeeding types are illustrated in Fig. 3. The following single new characters are successively added:

1. The *hypostyle,* the bud-outgrowth on the post-cingulum in *Mesohippus bairdii.*
2. The *crochet,* the bud-outgrowth on the metaloph of *Mesohippus trigonostylus, Miohippus brachystylus, M. gidleyi, Parahippus,* and all higher equines. Absent in *Kalobatippus* and *Hypohippus.*
3. Degeneration of *cingula,* last vestiges of internal cingulum being seen in *Miohippus, Anchitherium,* and *Hypohippus.*
4. Expansion of the *conules* (*pl, ml*), reduction of the *cones* (*pr, hy*), begun in *Miohippus,* continued in *Parahippus.*
5. Selenoid enlargement of the *conules* (*pl, ml*) begun in *Parahippus,* completed in *Merychippus.*
6. Forking or bifurcation of the *crochet* to form the *pli crochet* and the *pli caballin,* two of the enamel folds which lie within the prefossette and medivallum respectively, as well seen in *Merychippus isonesus primus* and *M. isonesus secundus.*



Parahippus ***Merychippus*** ***Merychippus***

Fig. 2. Accessory folds of the equine upper molars.
Upper molars of *Parahippus* and *Merychippus,* with key to same, showing the exact mode of origin of the accessory folds, or *plicas,* arising from the primary cones, conules, and lophs.

7. *Forking or bifurcation of the hypostyle* to form the *pli hypostyle* within the postfossette and postvallum, as seen in *Merychippus isonesus primus* and *M. isonesus secundus.*
8. *Infolding of the protoconule* within the prefossette to form the *pli protoconule.*
9. *Ptychoid foldings, or plications, of the anterior enamel wall of the metaloph* are seen in *Parahippus crenidens, P. cognatus* (Plates 8, 9) and more advanced stages, to form the *pli prefossette.*
10. *Ptychoid plications of the posterior enamel wall of the metaloph,* beginning in *Merychippus isonesus primus, M. isonesus secundus* and higher stages, to form the *pli postfossette.*
11. *Reduplication or doubling of the pli caballin, pli crochet, pli hypostyle,* observed in progressive species of *Merychippus, e. g. M. paniensis, M. sphenodus, M. calamarius, M. republicanus,* to form double or triple plications.

All these secondary enamel foldings and plications are characters primitively confined to the summit, the upper third, or upper half of the crown of the tooth; they may disappear entirely as the crown becomes worn down, as shown in *Merychippus sejunctus* in three stages of wear (Plate 16.1,3).

The term or prefix *pli* is taken from the old French term *pli caballin,* derived from the Latin *plica.* See Fig. 2.

crochet	forward fold from the metaconule
pli crochet ^{1}	superior fold of the crochet (Fig. 3)
pli hypostyle ^{1}	antero-external fold of the hypostyle
pli caballin ^{1}	fork of the crochet into the medivallum
pli caballin ^{2}	“ “ “ “ reduplicate
pli prefossette	fold of the metaloph into the prefossette
pli hypostyle ^{2}	duplication of the pli hypostyle
pli crochet ^{2}	duplication of the superior pli crochet
pli postfossette ^{1}	fold of the metaloph into the postfossette
pli postfossette ^{2}	“ “ “ “ reduplicate
pli protoconule	fold of the protoconule (*pli protoconule,* Fig. 2) into the prefossette
pli crochet ^{3}	superior triplicate fold of the crochet

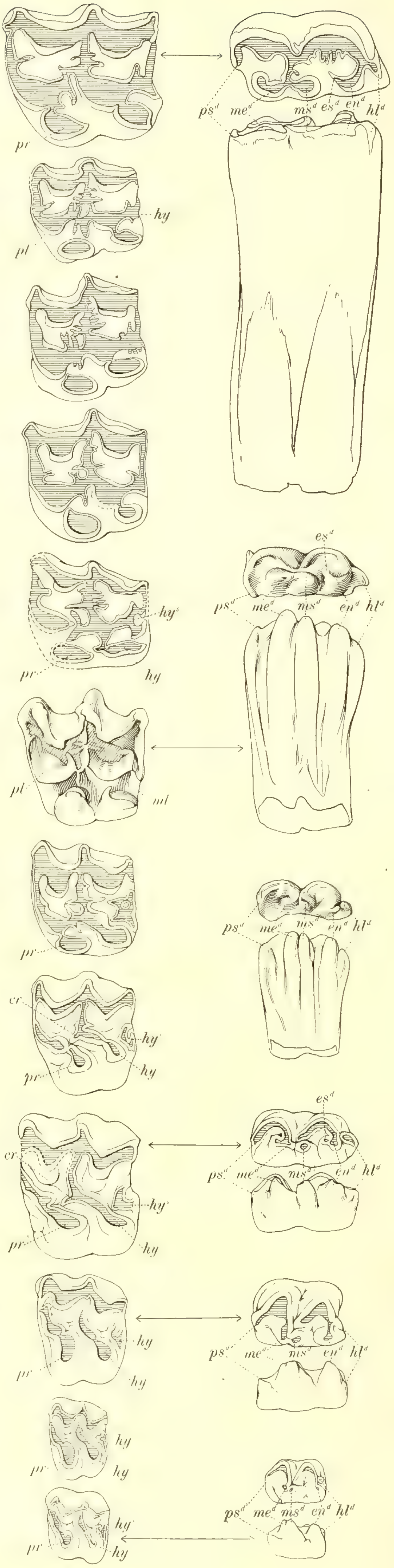


Fig. 3. EVOLUTION OF UPPER AND LOWER EQUINE MOLARS.

(Left) Component cones, crescents, crests, styles, crochets, and plicas of upper molars in Oligocene to Pliocene stages of evolution.

(Right) Component elements forming the six columns on the internal face of the lower molars, namely: parastylid, metaconid, metastylid, entostylid, entoconid, hypoconulid.

ps^d	parastylid	es^d	entostylid
me^d	metaconid	en^d	entoconid
ms^d	metastylid	hl^d	hypoconulid

Pliohippus leidyanus Osborn, Amer. Mus. 17224. (Left) p^3 of type.

Merychippus paniensis Cope, Amer. Mus. 9460, p^3, referred specimen.

Merychippus republicanus Osborn, Amer. Mus. 8347, p^3 of the type.

Merychippus ?sphenodus Cope, Amer. Mus. 8281, cotype. (Reversed in drawing).

Hipparion coloradense Osborn, Amer. Mus. 9094, type. (Reversed in drawing).

Merychippus calamarius Cope, Amer. Mus. 14014, referred specimen. (Unworn, without cement.)

Merychippus isonesus tertius Osborn, Amer. Mus. 14180, m^2 of the type.

Parahippus brevidens Marsh, Yale Mus. 11274, type.

Parahippus texanus Leidy, Amer. Mus. 12924, m^2, referred specimen.

Miohippus gemmarosæ Osborn, Amer. Mus. 13808, m^1 of the type. (Reversed in drawing.)

Mesohippus bairdii Leidy, Amer. Mus. 1477, m^2 of neotype.

Mesohippus hypostylus Osborn, Amer. Mus. 1180, m^1 of type.

Pliohippus leidyanus Osborn, Amer. Mus. 17224, p_4 of type, crown and outer view.

Outer view.

Merychippus calamarius Cope, Amer. Mus. 13901a, referred m_2. (Reversed in drawing.)

Inner view.

Merychippus isonesus primus Osborn, Amer. Mus. 14187, m_1 of the type.

Inner view.

Parahippus, Amer. Mus. 14305, m_1.

Inner view.

Miohippus gemmarosæ Osborn, Amer. Mus. 12928, m_1 of paratype.

Inner view.

Mesohippus bairdii, referred specimen, Amer. Mus. 12287, m_1.

Inner view.

The evolution of these dental characters may be very readily followed in the comparative drawings of the grinding teeth (Plate 3), also the profound changes of proportion observed at different planes from the summit to the base. The transverse diameters remain nearly the same while the anteroposterior diameters rapidly decrease.

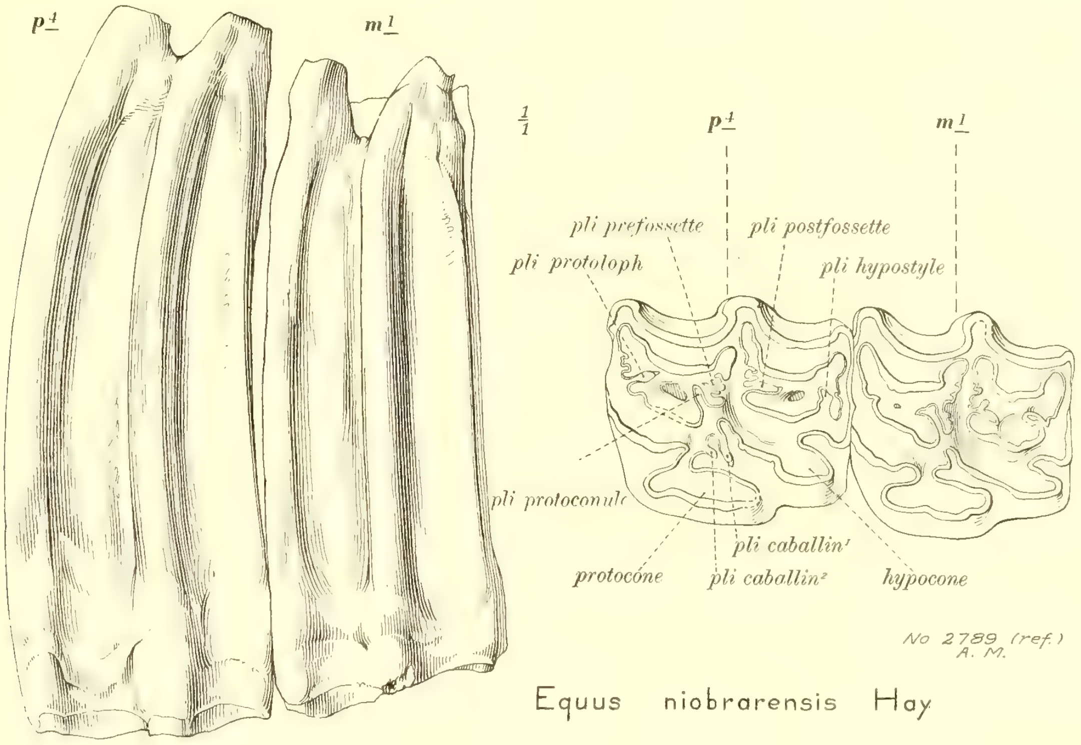


Fig. 4. *Equus niobrarensis* Hay, referred specimen, Amer. Mus. 2789. Left fourth superior premolar and first molar, p^4–m^1. From the Hay Springs Quarry, western Nebraska, Equus zone, Lower Pleistocene. Natural Size.

The evolution of the lower molar teeth is correctly interpreted in Figs. 1, 3. It may be readily traced from *Mesohippus* into *Pliohippus* (Fig. 3) and thence into *Equus* (Fig. 4a). The six columns rise on the internal side of the crown from before backward, as follows:

Inner side

ps^d	*parastylid*	at the antero-internal angle
me^d	*metaconid*	metaconid, main column
ms^d	*metastylid*	" accessory column
es^d	*entostylid*	rudimentary accessory column of entoconid
en^d	*entoconid*	main column of entoconid
hl^d	*hypoconulid*	" " " hypoconulid

Outer side

Ectostylid	accessory external column between trigonid and talonid in cleft of outer wall.

CHIEF GEOLOGIC HORIZONS, FORMATIONS, LEVELS, AND LIFE ZONES CONTAINING REMAINS OF EQUIDÆ.[1]

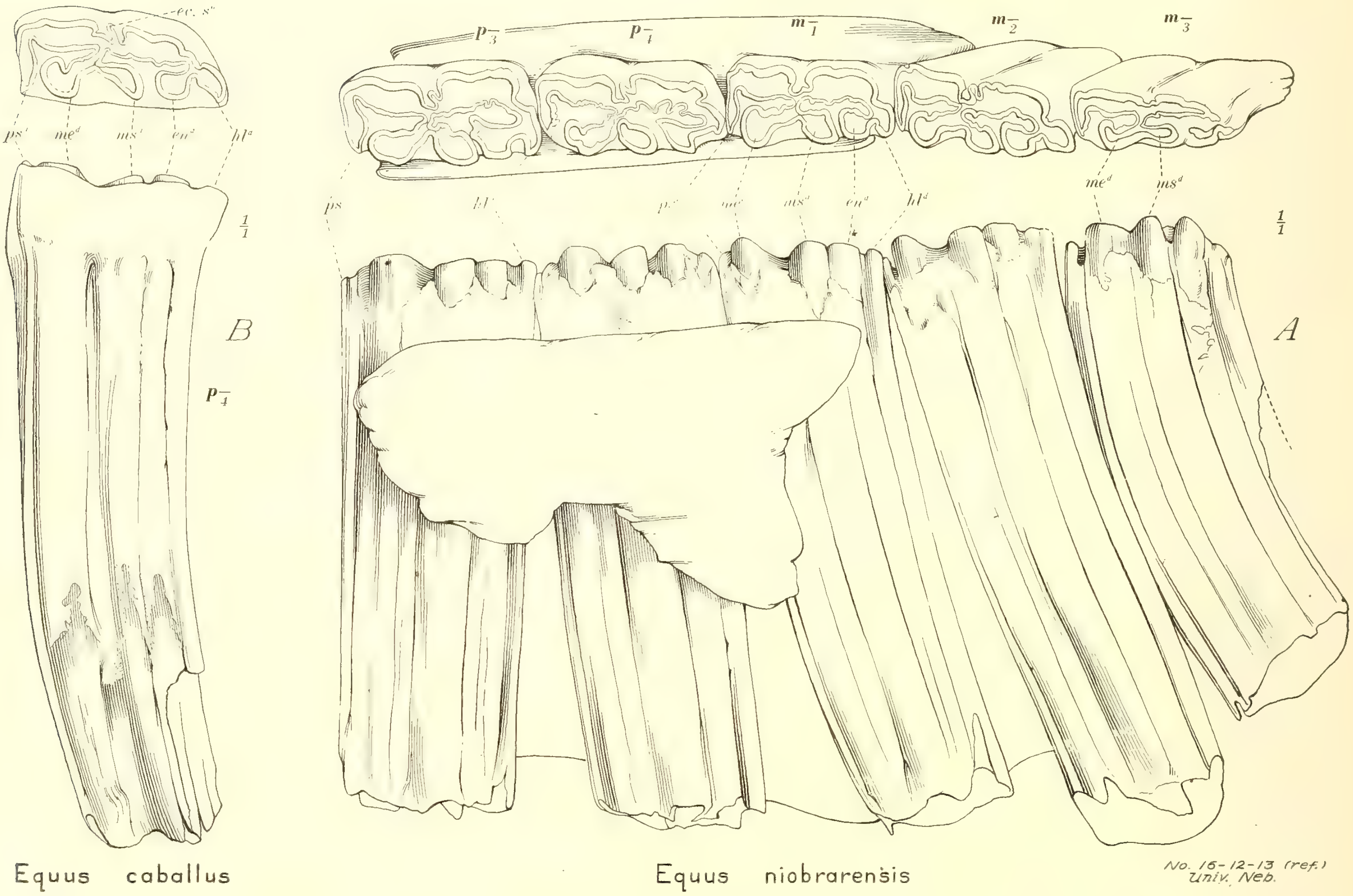


Fig. 4a. Inferior Molar Pattern of *Equus niobrarensis* Hay, to be compared with that of *Pliohippus leidyanus* Osborn.

A *Equus niobrarensis* Hay, Univ. Nebraska Coll. 16–12–13, referred specimen, left lower jaw containing p_3–m_3 (reversed in drawing). Locality, Crete, Nebraska, attributed to Aftonian Interglacial stage.

B *Equus caballus*, Amer. Mus. Coll. 4th inferior premolar of the right side. Selected as the most elongate, hypsodont, molar in a very large collection.

Geologic correlation. The geologic correlation in this Memoir is provisional because in many of the formations, beds, and horizons the fauna is imperfectly known or imperfectly determined at present.

The chief departure from the previous geologic correlations by Osborn and Matthew[1] is in the lower and upper boundaries of the Miocene. The lower boundary of the Miocene is now made to include the Promerycochœrus-Miohippus zone of the Upper John Day, the Lower Harrison, and the Lower Rosebud. The Upper Miocene is made to conclude with the progressive species of *Merychippus,* such as *M. calamarius* of the lower portion of the Santa Fé marls and of Barstow, California.

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[1] Osborn, H. F. and Matthew, W. D. "Cenozoic Mammal Horizons of Western North America, with Faunal Lists of the Tertiary Mammalia of the West," *Bull. U. S. Geol. Surv.* 361, Jan. 1909, pp. 1–138.

The Pliocene is here made to commence with the appearance of the *Procamelus-Hipparion* fauna, so that it includes the Ricardo of the Pacific coast, the Niobrara River near Ft. Niobrara, the Little White River of South Dakota, and many other localities where the full *Procamelus-Hipparion* fauna has been found. Doubtless many of these formations overlap the close of the Miocene and beginning of the Pliocene.

This change has been made with the full concurrence of Matthew and Merriam and conforms with the previous conclusions of Scott. It does not as yet rest on the secure foundations of comparison with the marine Lower Pliocene fauna. Yet Merriam observes (letter, February 28, 1917): "With reference to this point it may be stated that the evidence of percentages of extinct species in the invertebrate Pliocene fauna of California seems very different from that of the latest Miocene of Europe, and much more like the percentage in the Pliocene." These most recent views of Merriam are presented in the accompanying correlation sheets (Figs. 13, 16).

The dates of the names assigned to formations, beds, etc., are taken chiefly from "North American Geologic Formation Names" by F. B. Weeks.[1] The formations are grouped under life zones.

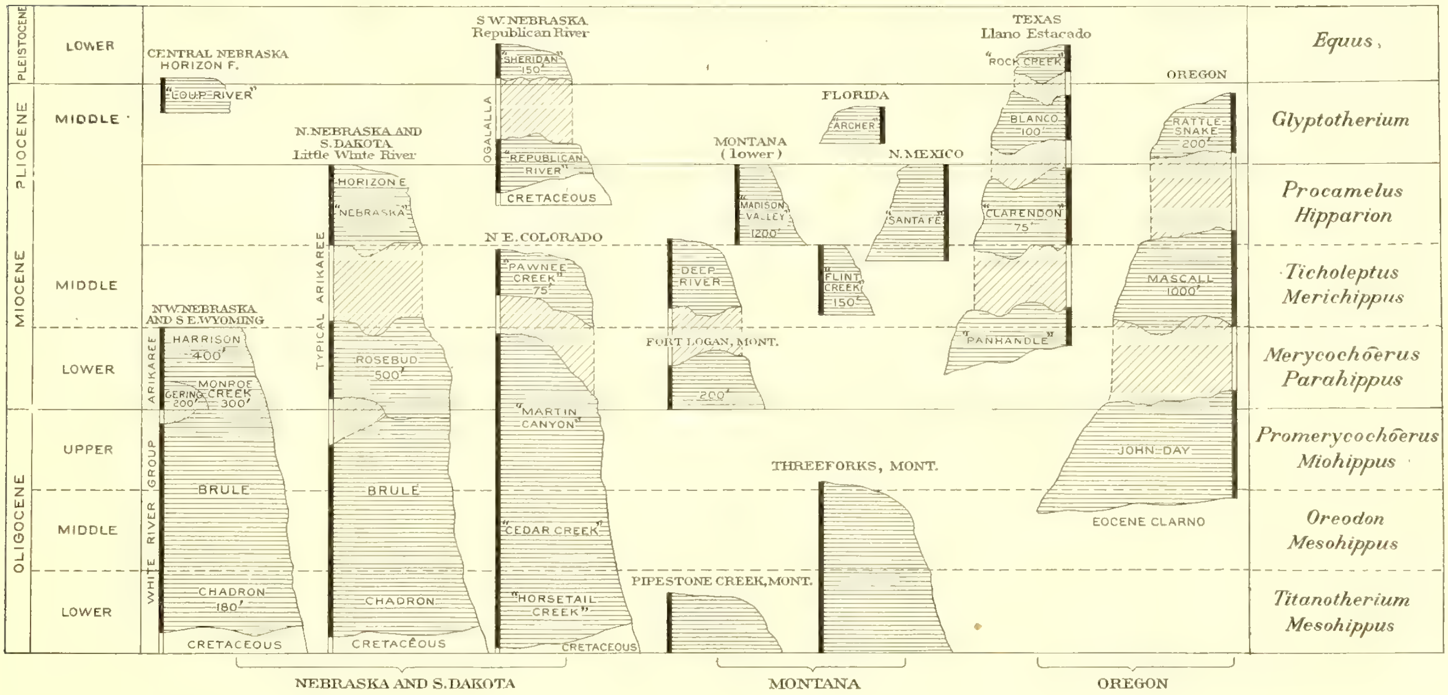

Fig. 5. General correlation of the fossil bearing horizons of the western plains district and of Oregon. The "Loup River" is now regarded as Lower Pleistocene, Equus excelsus-Elephas imperator zone. The Procamelus-Hipparion zone is now included in the Pliocene. Modified after Osborn and Matthew, 1909.

TITANOTHERIUM-MESOHIPPUS ZONE. LUDIAN (SUPÉR.), SANNOISIAN, STAMPIAN, OF EUROPE.

1. Horizon A of Hayden and Leidy, 1869, lower part of the White River series, South Dakota.
    2. Titanotherium beds, South Dakota, Hayden and Leidy, 1869.
    3. Chadron formation, South Dakota, 200 ft., Darton, 1905.
4. Horsetail Creek beds, northeastern Colorado and western Nebraska, Matthew, 1901.
5. Monument Creek formation (upper part), Darton, 1905, 1906.
6. Pipestone Creek beds, Thompson Creek, western Montana, Douglass 1899, 1901, 1903.
7. Swift Current Creek, Cypress Hills, British Columbia, Cope, 1885.

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[1] *Bull. U. S. Geol. Surv.* No. 191, 1902.

Lower Titanotherium Zone.

Type of *Mesohippus celer* Marsh, 1874.
" " " *westoni* Cope, 1889.
" " " *montanensis* Osborn, 1904.2.

Type of *Mesohippus latidens* Douglass, 1904.1.
? " " " *portentus* " 1908.

? Titanotherium Zone — Leptauchenia Zone.

Type of *Mesohippus præcocidens* Lambe, 1905.1.
" " " *propinquus* " 1905.2.

Type of *Mesohippus planidens* Lambe, 1905.4.
? " " " *assiniboiensis* Lambe, 1905.5.

Upper Titanotherium Zone.

Type of *Mesohippus hypostylus* Osborn 1904.3.

Type of *Mesohippus proteulophus* Osborn 1904.4.

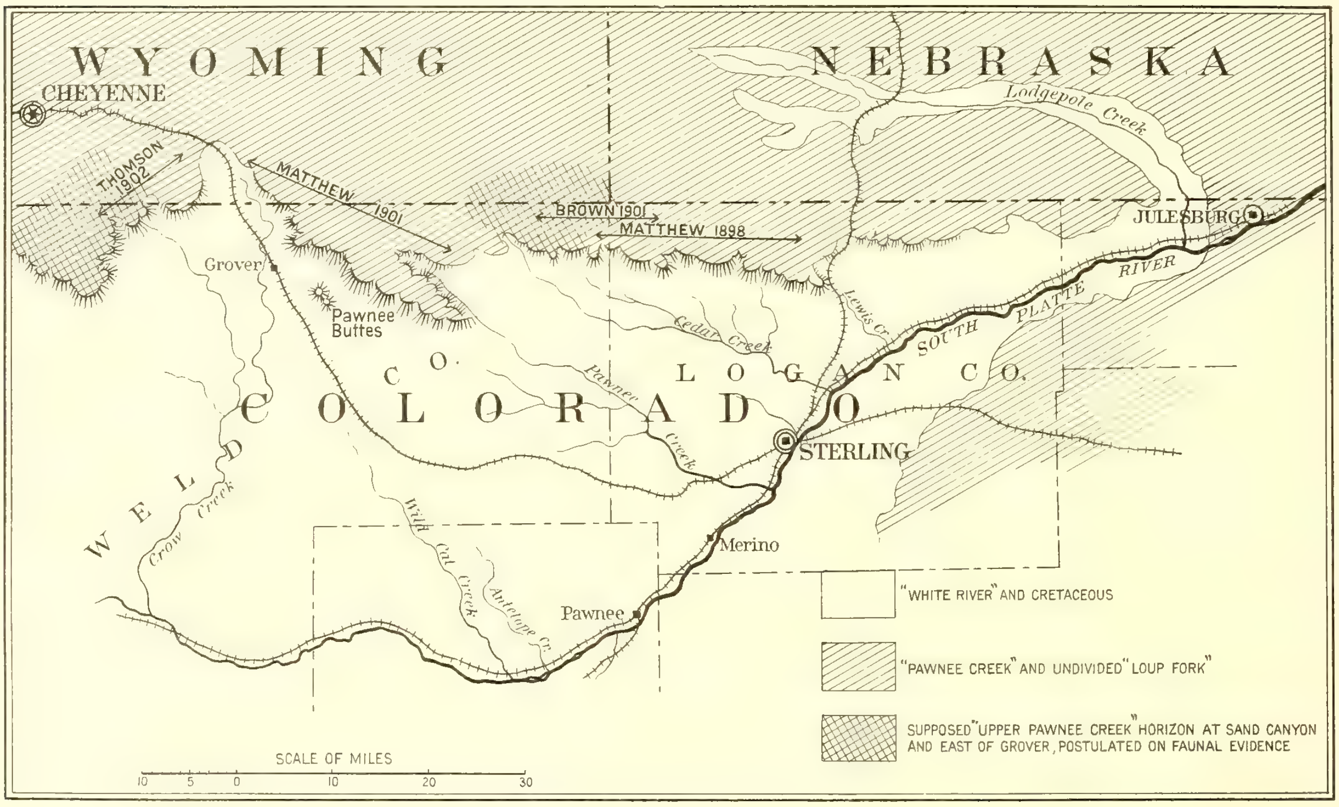


Fig. 6. Oligocene (Cedar Creek), Middle Miocene (Pawnee Creek), and Lower Pliocene (Upper Pawnee Creek) exposures of northwestern Colorado. Areas explored by the American Museum of Natural History in 1898, 1901, 1902, by Messrs. Matthew, Brown, and Thomson.

Oreodon-Mesohippus Zone. Stampian, Oligocène Moyen of Europe.

1. White River group (in part), Meek and Hayden, 1862.
   1*a*. Bear Creek, Pennington County, South Dakota, 1850.
   2. Horizons B and C, South Dakota, Hayden and Leidy, 1869.
   3. Oreodon beds of Leidy, South Dakota, 1869.
   4. Middle portion of Big Badlands, Cheyenne River, South Dakota.
   5. Brule Clays, lower levels, South Dakota, Darton, 1899.

6. Cedar Creek beds,[1] northeastern Colorado, Matthew, 1901.
7. Hat Creek beds, Wyo., Reed, Hatcher.
8. Exposures of similar age in Wyoming, South Dakota, northwestern Nebraska, western Montana, usually described as "White River beds," "White River Group." (Exact geologic level uncertain.)

Type of *Mesohippus exoletus* Cope, 1874.1. Type of *Mesohippus cuneatus* Cope, 1873.1.
? Type of *Mesohippus eulophus* Osborn, 1904.6.

Bear Creek, Pennington Co., South Dakota, Culbertson, 1850.

From the published field notes of Thaddeus Culbertson (*Fifth Ann. Rept. Smiths. Inst.*, 1850) and from a later report by Hayden (*Proc. Acad. Nat. Sci. Phila.* 1857, p. 151), Gidley is of the opinion (letter, October 20, 1917) that all the collecting of the early expeditions in the "Mauvaises Terres of Nebraska" was confined to a single area about five miles in extent, near the head of Bear Creek, about eight or ten miles north of Sheep Mountain of the Big Badlands, and that none of these expeditions ever entered the afterward famous Indian Creek-Corral Draw Basin locality, now known as the Big Badlands. The type locality of *Mesohippus bairdii* and its associated fauna can probably be stated as the head of Bear Creek, Pennington County, South Dakota, from which Leidy noted that several tons of material were taken by the early expeditions.

Type of *Mesohippus bairdii*, 1851.

Lower Oreodon Zone.

Neotype of *Mesohippus bairdii* Leidy, 1851.

Metamynodon Zone (=lower levels of Middle Oreodon Zone). Stampian, Oligocéne Moyen of Europe.

1. Metamynodon sandstones, South Dakota, Wortman, 1893. River channel sandstones in Lower Oreodon zone or lower Brule Clay, all continuous.

Type of *Mesohippus trigonostylus* Osborn, 1918. Paratype of *M. trigonostylus* Osborn, 1918

Middle Oreodon Zone (= level of Metamynodon Zone). Stampian or Oligocéne Moyen of Europe.

Type of *Mesohippus obliquidens* Osborn, 1904.5.

Upper Oreodon Zone.

1. Upper Oreodon layer 75–100 ft., Wortman, 1893.
2. Similar levels at Cedar Creek, Col., Hat Creek, Wyo., and other exposures in South Dakota and northwestern Nebraska.

? Type of *Mesohippus eulophus* Osborn, 1904.6.

Protoceras Zone and Leptauchenia Zone, contemporaneous early phases of Upper Oligocene.

1. Horizon C (in part), South Dakota, Hayden and Leidy, 1869.
   2. Upper part of White River group of South Dakota, Meek and Hayden (in part), 1869.
   3. Leptauchenia clay layer (= lower and upper levels), Wortman, 1893. Plains fauna.

---

[1] Matthew observes (1916) that it is quite likely that a large part of the fossiliferous areas of the Cedar Creek beds are Upper Oreodon zone and that *M. eulophus* may be from those upper layers, but there is no positive record of it.

4. Protoceras sandstones, Wortman, 1893, lower levels. Forest and fluviatile fauna.
5. Brule clays (upper levels of), Darton, 1899.
6. Martin Cañon beds, northeastern Colorado, Matthew, 1901.
7. White Buttes, North Dakota, Douglass, 1907.
8. Blacktail Deer Creek, Montana.
9. (*Incertæ sedis*) Gering formation, western Nebraska, Darton, 1899. Typical horizon at Scott's Bluffs.

Protoceras Sandstones, River Channel Beds, usually in Middle levels.

The Protoceras sandstones are equivalent in time to the middle Leptauchenia depositions or begin with the upper Leptauchenia depositions (J. W. G. 1917).

Type of *Miohippus validus* Osborn, 1904.3.
“ “ “ *gidleyi* Osborn, 1904.4.

Type of *Miohippus intermedius* Osborn and Wortman, 1895.
“ “ “ *crassicuspis* Osborn, 1904.5.

Leptauchenia-Miohippus Zone (= Upper Level of Brule Clays).

Type of *Miohippus meteulophus* Osborn, 1904.1.

Type of *Miohippus brachystylus* Osborn, 1904.2.

Diceratherium-Miohippus Zone, second phase of Upper Oligocene. Aquitanian of Europe.

1. John Day formation (Middle), Oregon, Marsh, 1875, Cope, Wortman, Merriam, Sinclair.
2. Diceratherium beds, 500 to 1,000 ft., Wortman, Merriam 1901.
3. (*Incertæ sedis*) Monroe Creek formation, western Nebraska, Hatcher, 1902.

John Day, Middle.

The geologic level of Cope's types of *Miohippus equiceps*, *M. brachylophus*, *M. longicristis*, also of Marsh's types is inferred from the surrounding *green matrix* characteristic of Middle John Day; also from the records of "The Cove," a locality exposing principally Middle John Day.

Type of *Miohippus anceps* Marsh, 1874.2.
“ “ “ *equiceps* Cope, 1878.1.
“ “ “ *brachylophus* Cope, 1878.2.

Type of *Miohippus longicristis* Cope, 1878.3.
“ “ “ *primus* Osborn, 1918.1.
“ “ “ *quartus* Osborn, 1918.2.

Promerycochœrus-Miohippus Zone, late phase of Upper Oligocene (Aquitanian of Europe) or Lower Miocene.

1. Upper John Day beds, Ore., Cope, Wortman, Merriam, Sinclair.
2. Promerycochœrus beds of authors. *Promerycochœrus*, a widely distributed oreodont.
3. Arikaree formation (in part), western Nebraska, Darton, 1899 (= Gering, Monroe Creek, Harrison, etc.).
4. (*Incertæ sedis*) Munroe Creek, western Nebraska, Hatcher, 1902 (= Lower Arikaree, Darton, probably = Lower Rosebud, Peterson, Thomson).
5. Fort Logan beds, Mont., Douglass, 1903.
6. Lower Rosebud, Matthew, Gidley, 1904, Matthew, 1907.

Upper John Day.

Chiefly gray matrix, locality Bridge Creek, John Day Basin, Ore.

Type of *Miohippus condoni* Leidy, 1871.
“ “ “ *annectens* Marsh, 1874.1.

Type of *Kalobatippus præstans* Cope, 1879.
“ “ *Miohippus acutidens* Sinclair, 1905.

Lower Harrison, Western Nebraska.

A number of species of horses have been found by Harold Cook in the Lower Harrison but have not yet been determined or described. They represent the genera *Parahippus* and *Kalobatippus.*

Type of *Kalobatippus agatensis* Osborn, 1918.

Type of *Parahippus tyleri* Loomis, 1908.2.

Lower Rosebud, South Dakota.

Type of *Miohippus equinanus* Osborn, 1918.3.

" " " *gemmarosæ* Osborn, 1918.4.

Type of *Parahippus pristinus* Osborn, 1918.1.

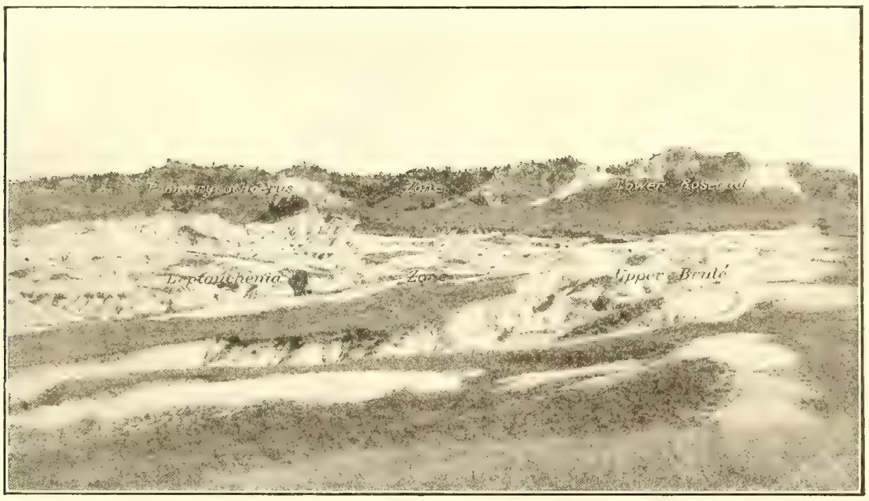


Fig. 7. Exposures of the Lower Miocene (Lower Rosebud), Promerycochœrus-Miohippus zone, overlying Upper Oligocene (Brule), Leptauchenia-Miohippus zone, Porcupine Creek, South Dakota. Photograph by the American Museum of Natural History.

MERYCOCHŒRUS-PARAHIPPUS ZONE. LOWER MIOCENE. BURDIGALIAN OF EUROPE.

This life zone is distinguished by the first appearance of the widespread oreodont genus *Merycochœrus,* a genus which survives into the Middle Miocene, also by the abundance of *Parahippus,* and by camels of more advanced type (*Oxydactylus*). *Oxydactylus, Ticholeptus, Blastomeryx* first appear here.

1. Horizon D of Hayden, 1869.
2. Upper Harrison formation, western Nebraska, Hatcher 1902, Peterson, 1906.
3. Upper Rosebud, South Dakota, Matthew, 1904.
4. Martin Cañon beds, northeastern Colorado, Matthew, 1901.
5. Laramie Peak, Wyoming.

Upper Harrison.

Type of *Parahippus nebrascensis* Peterson, 1907.3.

Type of *Parahippus nebrascensis primus* Osborn, 1918.4.

Type of *Parahippus pawniensis atavus* Osborn, 1918.3.

Upper Rosebud.

Type of *Parahippus coloradensis præcurrens* Osborn, 1917.2.

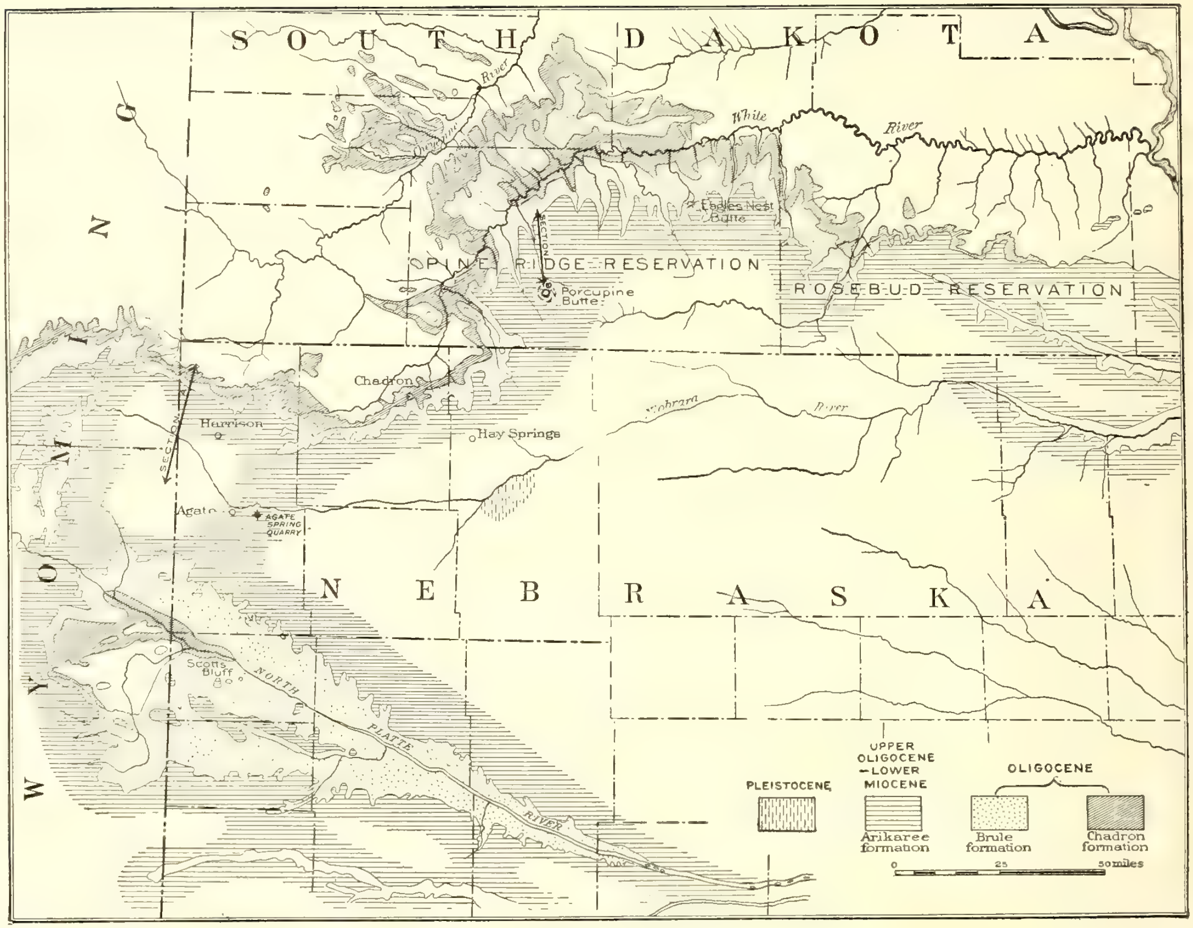
Washington Co. (*Incertæ sedis*), Texas.

Type of *Parahippus texanus* Leidy, 1868.

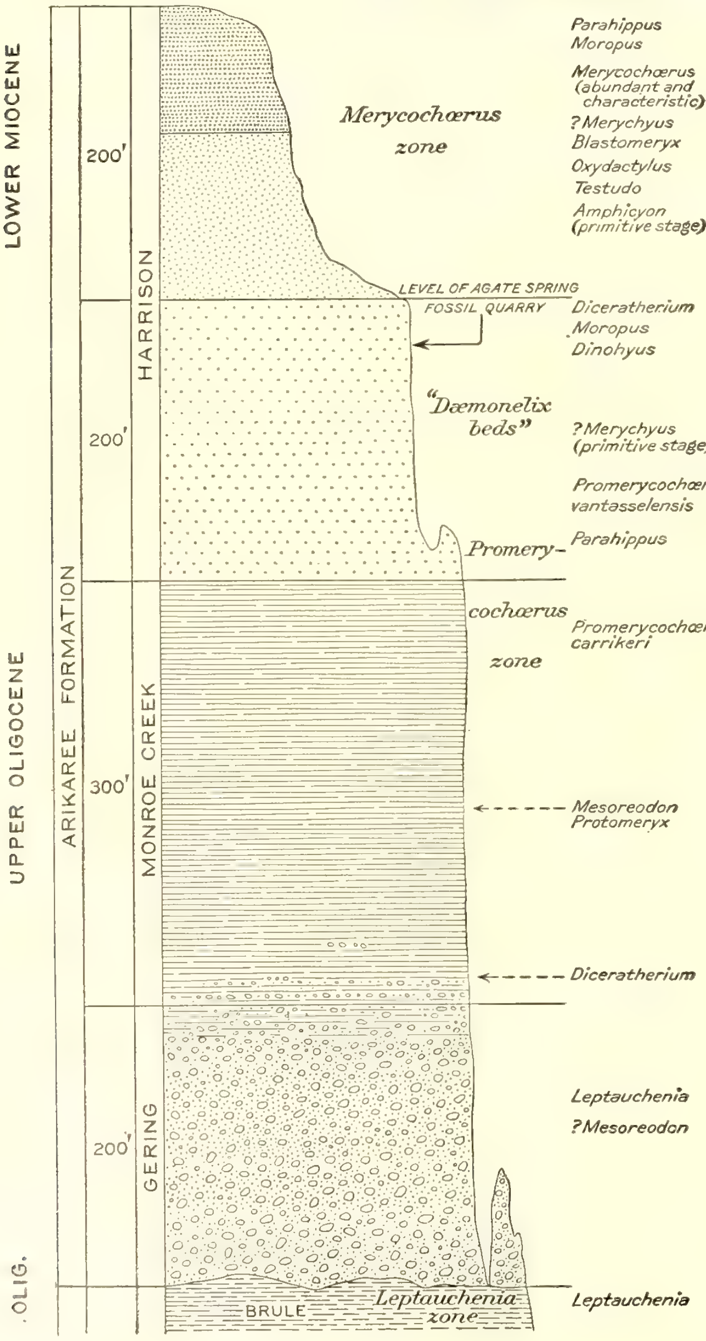
Type of *Parahippus australis* Leidy, 1873.1.

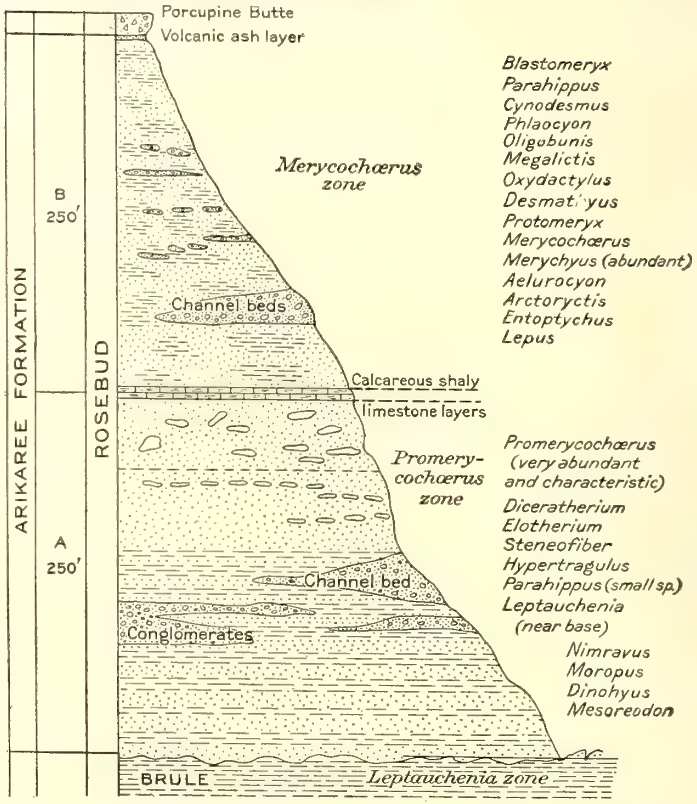
Fig. 8. Upper Oligocene–Lower Miocene Exposures of Western Nebraska.

A Lower Miocene (Harrison, Rosebud) of Western Nebraska and South Dakota.



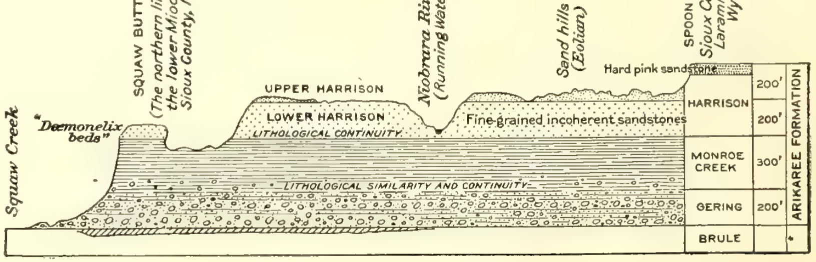
B Lower Miocene, resting on Brule, generalized section at Agate, western Nebraska.





C Lower Miocene (Rosebud) resting on Brule (Oligocene), near Porcupine Butte, South Dakota.

D Section of the Lower Miocene west of Harrison, Nebraska.


Squaw Creek
"Dæmonelix beds"
SQUAW BUTTE
(The northern limit of the lower Miocene) Sioux County, Nebr.
UPPER HARRISON
LOWER HARRISON
LITHOLOGICAL CONTINUITY
Niobrara River (Running Water)
Sand hills (Eolian)
SPOON BUTTE
Sioux County, Nebr. Laramie County, Wyo.
Hard pink sandstone
Fine-grained incoherent sandstones
LITHOLOGICAL SIMILARITY AND CONTINUITY
HARRISON
MONROE CREEK
GERING
BRULE
200'
200'
300'
200'
ARIKAREE FORMATION

Fort Logan, Montana.

Type of *Parahippus taxus* Douglass, 1908.2.

Incertæ sedis, Montana.

Type of *Parahippus agrestis* Leidy, 1873.2.

Ticholeptus-Merychippus Zone, Middle Miocene. Successive Helvetian, Sarmatian, Tortonian Stages of Europe.

This zone is characterized by the continuation, in Montana, of the oreodont *Ticholeptus*, by the rare survival of *Parahippus*, by the first appearance of a pro-*Merychippus* (*P. brevidens* of the Mascall), and by the first appearance of *Hypohippus* and *Archæohippus*. The name "Ticholeptus beds," applied by Cope, is not distinctive and may be replaced by "Ticholeptus-Merychippus zone," owing to the continuation in Montana of the oreodont *Ticholeptus*.

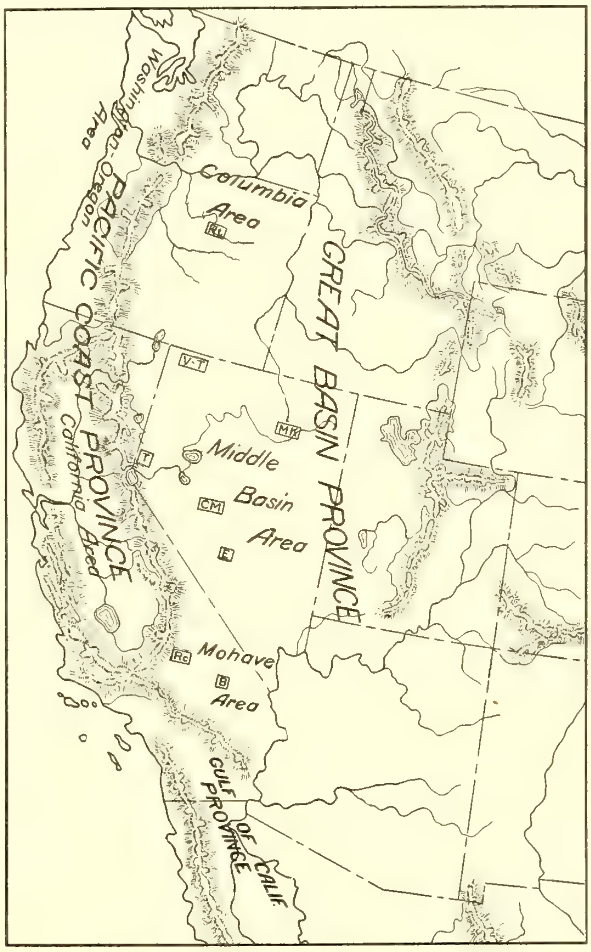


Fig. 9. Outline map of the chief Tertiary mammal localities in the United States west of the Wasatch range.

CM Cedar Mountain beds, E Esmeralda, T Truckee, MK McKnight Miocene, V–T Virgin Valley and Thousand Creek beds, Rt Rattlesnake beds and Mascall, Rc Ricardo beds, B Barstow beds. After Merriam, 1916, Pl. 8.

1. Horizon E, central plains, Hayden and Leidy, 1869.
2. Mascall formation (overlying John Day formation), Ore., Cope, 1879, Merriam, 1901.
3. Ticholeptus beds, Montana, Cope, 1879.

4. Deep River (Smith Creek), Montana, Cope 1879, Scott 1893–1894, Douglass, 1899.
5. Pawnee Creek beds, northeastern Colorado, Matthew, 1901.
?6. Flint Creek beds, Montana, Douglass, 1903. More probably Lower Pliocene.
7. "Loup Fork" beds in part, Colorado and Oregon, Cope.
8. Panhandle beds, northwestern Texas, Gidley, 1903.
9. Sheep Creek beds, western Nebraska, Matthew, 1909.
10. "Temblor" (Anderson, 1908), North Coalinga region, California, Merriam, 1915.
11. Alum Bluff, Liberty County, Florida, Sellards, 1916.

ALUM BLUFF, APALACHICOLA RIVER, LIBERTY COUNTY, FLA. SELLARDS, 1916.

To this newly described life zone are attributed *Parahippus leonensis* Sellards, *Merychippus* ?sp., *Mesocyon*, also remains referred to the camel *Oxydactylus* ?sp. and to *Leptomeryx*. The *Merychippus* is regarded by Merriam as close to the Phillips Ranch type of southern California (Merriam, letter Sept. 15, 1917).

Type of *Parahippus leonensis* Sellards, 1916.

Type of *Merychippus* ?sp. Sellards, 1916.

MASCALL, OREGON.

The equine and other mammalian stages of the Mascall, Ore., are slightly earlier than those of the Deep River, Montana. Merriam (*Trans. Am. Philos. Soc.*, 1915, p. 216) observes that the Mascall and Virgin Valley formations of the Great Basin region are approximately of the same age as or older than the "Temblor."

Type of *Parahippus avus* Marsh, 1874.
" " *Archæohippus ultimus* Cope, 1886.
" " *Parahippus brevidens* Marsh, 1874.4.
" " *Kalobatippus gracilis* Marsh, 1892.

Type of *Merychippus seversus* Cope, 1878.
" " " *relictus* Cope, 1889.1.
" " " *isonesus* Cope, 1889.3.

DEEP RIVER, MONTANA.

This is regarded as slightly more recent than the Mascall.

Type of *Parahippus crenidens* Scott, 1893.

Type of *Hypohippus equinus* Scott, 1894.

SHEEP CREEK, WESTERN NEBRASKA.

The Sheep Creek deposits doubtless extend over a considerable period of time. They have yielded referred specimens of *Parahippus avus*, also a series of primitive types of *Merychippus* (*M. isonesus primus* Osborn) which lead into more progressive types (*M. isonesus quintus* Osborn). The geologic distribution of these ascending mutations which lead up into *Merychippus seversus* or *M. isonesus* is indicated in the accompanying diagram. This series of *Merychippus* are less primitive than the *Parahippus brevidens* Marsh of the Mascall.

A referred specimen, *M. isonesus primus* Osborn (Amer. Mus. 14179a), was found about a half a mile away, apparently at a lower geologic level than the type of this species, Amer. Mus. 14187. A referred specimen of *Parahippus avus* (Amer. Mus. 14182) came from the same locality as 14179–85.

RELATIONS OF THE PHILLIPS RANCH AND CACHE PEAK FAUNAS, TEHACHAPI, SOUTHERN CALIFORNIA.

"A comparison of the Phillips Ranch and Cache Peak faunas must at present be based largely upon the horses represented in the two collections. *Moropus* occurs only in the former fauna, while *Merycochœrus* (?) and *Dromomeryx* are found only in the latter, but the collections are not sufficiently large to make the absence of a form from one fauna and its presence in the other significant. *Merycodus* is present in the collections from both localities, but the material is too scanty to allow an accurate comparison." (p. 81.) "The faunas, consisting as they do in large part of horses, camels, and antelope-like forms, point to a plains or open valley environment in this region in middle Miocene time. The deposits in which the faunas occur are of types which suggest that they were laid down under subaërial conditions as waste slope and playa lake deposits; the evidence for this view is corroborated by the occurrence of the mammalian remains, which are usually scattered and frequently much gnawed by rodents."[1] (p. 84.) Phillips Ranch is regarded by Matthew (1916) as near Sheep Creek age, namely, Lower Middle Miocene.

Phillips Ranch, Lower Levels of Monolith Series, Tehachapi, Southern California.

This California horizon is regarded by Buwalda, Merriam, and Matthew as early Middle Miocene, Merychippus zone. It may be slightly older than the Sheep Creek of Nebraska as no types have been found here so hypsodont as the more progressive Sheep Creek mutations. The isolated molar teeth of *Merychippus* described by Buwalda are relatively short-crowned or intermediate in length.

Phillips Ranch, Age of.— "The horse material from Phillips Ranch resembles still less any of the horses found in the Ricardo Fauna, being much more primitive. It is likewise less advanced than the horse species obtained in the Tejon Hills in the southern San Joaquin Valley. The Phillips Ranch fauna certainly represents a stage of evolutionary development much earlier than the Barstow, Ricardo and Tejon Hills [Chanac] faunas."[1] (p. 82.)

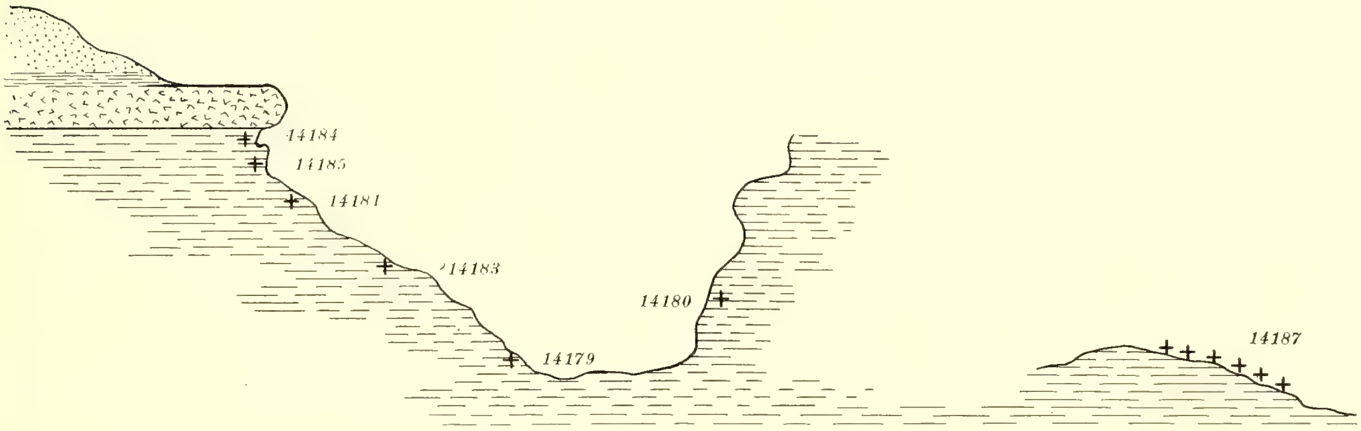


Fig. 9a. Geologic distribution in ascending order of mutations of *Merychippus isonesus* from Sheep Creek.

Amer. Mus. 14184, type of *M. isonesus quartus* Osborn; Amer. Mus. 14185, type of *M. isonesus quintus* Osborn; Am. Mus. 14181, specimen referred to *M. isonesus quartus* Osborn; Am. Mus. 14180, type of *M. isonesus tertius* Osborn; Am. Mus. 14179, type of *M. isonesus secundus* Osborn; Am. Mus. 14187, type and topotypes of *M. isonesus primus* Osborn, the most primitive form.

Virgin Valley, Nevada.

Of the same age as Mascall or slightly more recent. Merriam (*Trans. Am. Philos. Soc.*, 1915, p. 216) observes that the Mascall and Virgin Valley formations of the Great Basin region are approximately of the same age as or older than the "Temblor."

This horizon described by Merriam[2] contains referred specimens of *Parahippus, Merychippus isonesus, Hypohippus ?osborni, H. ?equinus;* also remains of *Moropus* ref. and *Merycodus furcatus* ref.

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[1] Buwalda, John P. "New Mammalian Faunas from Miocene Sediments near Tehachapi Pass in the Southern Sierra Nevada." *Univ. Cal. Publ. Bull. Dept. Geol.*, Vol. 10, No. 6, Nov. 18, 1916, pp. 75–85.

[2] Merriam, John C. *op. cit.*

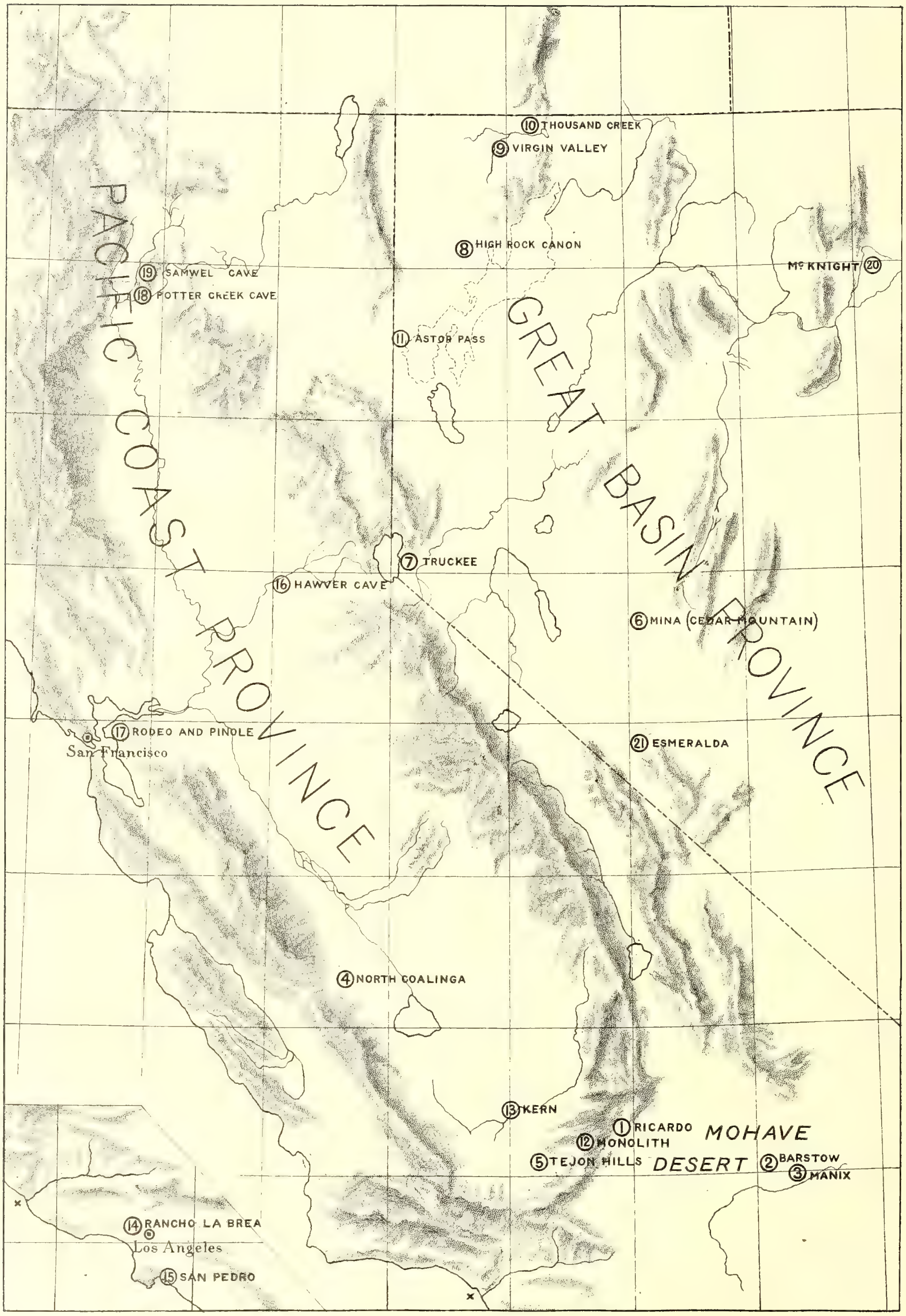

Fig. 10. Chief fossil bearing localities in California, Oregon, and Nevada. Areas of the explorations of the University of California under Professor John C. Merriam. Revised to include the year 1916.

1 Ricardo, Lower Pliocene.
2 Barstow, Upper Miocene.
3 Manix, Pleistocene.
4 North Coalinga, Temblor, Jacalitos.
5 Tejon Hills, Chanac.
6 Mina.
7 Pleistocene Foot Prints.
8 High Rock Cañon (fauna = Virgin Valley).
9 Virgin Valley, Middle Miocene.
10 Thousand Creek, Lower Middle Pliocene.
11 Astor Pass?
12 Monolith Series, Phillips Ranch, Cache Peak, Middle Miocene.
13 Kern.
14 Rancho La Brea, Pleistocene.
15 San Pedro?
16 Hawver Cave, Pleistocene.
17 Rodeo and Pinole?
18 Potter Creek Cave, Pleistocene.
19 Samwel Cave, Pleistocene.
20 McKnight?
21 Esmeralda?

Pawnee Creek, Northwestern Colorado.

This important and thoroughly explored region has yielded through the successive explorations of Cope, Matthew, and Thomson, the following important types of described species, which are regarded as typical Middle Miocene.

Type of *Parahippus pawniensis* Gidley, 1907.1.
" " " *coloradensis* Gidley, 1907.2.
" " *Merychippus paniensis* Cope, 1874.1.
" " " *labrosus* Cope, 1874.2.

Type of *Merychippus sejunctus* Cope, 1874.3.
" " " *sphenodus* Cope, 1889.2.
" " " *campestris* Gidley, 1907.
" " *Hypohippus osborni* Gidley, 1907.

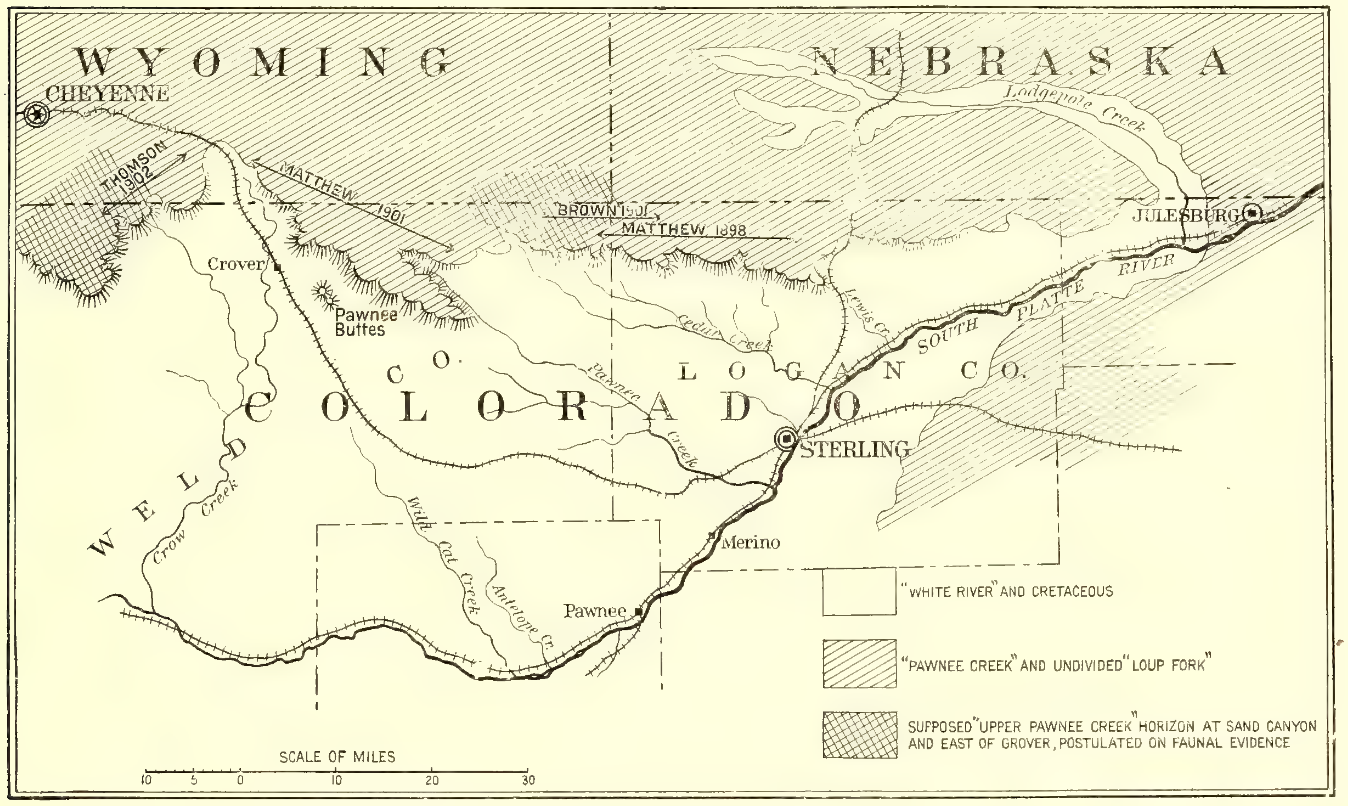

Fig. 10a. Oligocene (Cedar Creek), Middle Miocene (Pawnee Creek), and Lower Pliocene (Upper Pawnee Creek) exposures of northwestern Colorado. Areas explored by the American Museum of Natural History in 1898, 1901, 1902, by Messrs. Matthew, Brown, and Thomson.

The American Museum party of 1898 worked westward under Matthew to the head of Cedar (or Clear) Creek, (Brown) the character of the beds changing and the division lines breaking down. In 1901 the section near Pawnee Buttes was worked, showing the Pawnee Creek series above (Ticholeptus-Merychippus zone), directly overlying the Upper Oreodon zone. The Pawnee series appears to include two levels, as follows:

Typical "Pawnee Creek,"
True Merychippus Zone, upper Middle Miocene.

Merychippus sejunctus ref.
" *paniensis* "
" *sphenodus* "
" *campestris* "
" *eoplacidus* type
" *proparvulus* "
" *eohipparion* "

"Upper Pawnee Creek," Sand Cañon, also localities west of Grover, Col. Protohippus-Hipparion zone, Lower Pliocene.

Protohippus proplacidus, type
Pliohippus ref.
Hipparion ref.

Observations of Matthew on Typical Pawnee Creek, Merychippus Zone, Middle Miocene.

All the horses known from the typical Pawnee Creek are referable to *Merychippus*. They are more progressive than the *Merychippus* from the Sheep Creek or Mascall and foreshadow the distinct groups of Equidæ of the Upper Miocene, although all fall within the genus *Merychippus*. The Lower Pliocene groups more or less distinctly foreshadowed are:

Merychippus sejunctus = *Protohippus perditus* group
" *paniensis* = ?*Merychippus calamarius* group
" *sphenodus* = ?*Merychippus insignis* group
" *campestris* = *Pliohippus mirabilis* group
" *eoplacidus* = *Protohippus placidus* group
" *proparvulus* = *Protohippus parvulus* group
" *eohipparion* = *Hipparion occidentale* group

The horses include also successive mutations of the Pawnee Creek species and forms intermediate between characteristic Pawnee Creek stages, such as *M. sejunctus*, and those characteristic of the Niobrara and Little White River region. For example, there is a form much like *M. sejunctus*, but large, robust, with somewhat deeper preorbital fossæ, heavier limbs, and long feet. There is also a form of *Merychippus* with limbs having the lateral digits much reduced, and with moderately long-crowned teeth, to which the name *Merychippus coplacidus* may be given.

In all the typical Pawnee Creek species the milk premolars are uncemented when first erupted but acquire an imperfect coating of cement by the time they are well worn. They retain the low crowns of the milk premolars of *Parahippus*, but the metaconule is crescentiform and more or less completely united to the crochet; the permanent molars are nevertheless not so elongate as in *Protohippus* and *Hipparion*. They retain most or all of the distinctive generic characters of *Merychippus*.

Besides the specimens referable to the typical *M. sejunctus*, *M. labrosus*, *M. paniensis*, *M. sphenodus*, *M. campestris*, these typical Pawnee Creek beds yield the following new types:

Type of *Merychippus coplacidus* Osborn, 1918.6.
" " " *proparvulus* Osborn, 1918.7.
" " " *cohipparion* Osborn, 1918.8.

Cache Peak, Upper Levels of Monolith Series, Tehachapi, Southern California.

The horses of this level, according to Merriam, include species comparable to *Merychippus campestris* and *Hypohippus* of the typical Middle Miocene, Pawnee Creek, Col. There occur here also *Dromomeryx* and *Merycochœrus* (Buwalda).

"The Cache Peak fauna represents a stage in advance of that found at Phillips Ranch. The Cache Peak fauna may be late middle Miocene or upper Miocene; it may furnish a transition stage between the Phillips Ranch and the Barstow faunas, but it is much nearer to the Barstow than to the Phillips Ranch."[1]

Barstow, Mohave Desert, Southern California, of Upper Miocene Age (Merriam, 1917).

As described by Merriam this horizon contains a rich horse fauna, apparently covering the transition period between the typical *Merychippus* zone and the *Protohippus* zone. The equines are referred to the genera *Parahippus* (*Archæohippus*), *Hypohippus*, *Merychippus*, and *Protohippus*. The true *Merychippus calamarius* is believed to occur here, which is a late Miocene species. The horizon is regarded by Matthew as a very late phase of the Miocene, near the top of the Merychippus zone, later than the typical Pawnee Creek of Colorado, and earlier than the Lower Pliocene formation of the Niobrara River. Merriam (1917) considers it Upper Miocene. The types recorded here are:

Type of *Archæohippus mourningi* Merriam, 1913.
Type of *Merychippus* (*calamarius*) *sumani* 1915.2.
Type of *Merychippus* (*Protohippus*) *intermontanus* Merriam, 1915.3.

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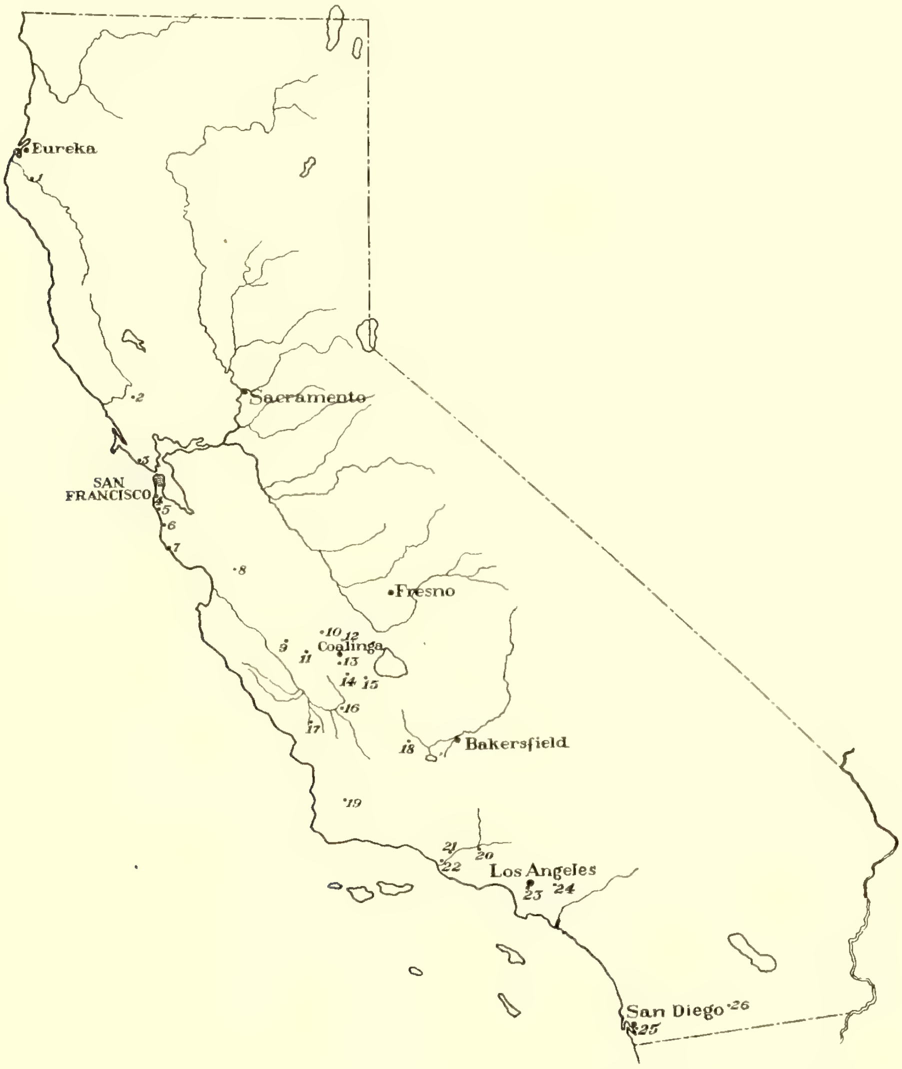
[1] Buwalda, John P. "New Mammalian Faunas from Miocene Sediments near Tehachapi Pass in the Southern Sierra Nevada," *Univ. Cal. Publ. Bull. Dept. Geol.*, Vol. 10, No. 6, Nov. 18, 1916, pp. 75–85 (p. 83).

Cedar Mountain, Ione Valley and Stewart Valley, Nevada, Buwalda, 1914.

"The faunal assemblage obtained in the Cedar Mountain region shows affinity with the Middle Miocene of Virgin Valley, but most nearly approaches the faunal stage of the Barstow Upper Miocene. .... Several differences between the Cedar Mountain and Barstow faunas may be due to geographic variation or may indicate that the Cedar Mountain beds cover a somewhat longer time range, including both older and younger beds than those from which collections have been obtained in the Barstow (p. 169). . . .On the whole there seems good reason for considering the Cedar Mountain fauna as near the Barstow and the Santa Fe in stage, ... " (p. 172) (Merriam, 1916).



Map of California Showing Important Pliocene Localities. 1. Wildcat Series at Eel River. 2. Wilson's Ranch near Santa Rosa. 3. Bolinas Bay. 4. Merced Series, type section. 5. Purisima. 6. Pescadero. 7. Año Nuevo Bay. 8. Sargent and Chittenden. 9. Lonoak. 10. Cantua Creek. 11. Priest Valley. 12. Coalinga Anticline. 13. Jacalitos Hills. 14. Kreyenhagen Hills. 15. Kettleman Hills. 16. Cholame Valley. 17. Paso Robles. 18. McKittrick. 19. Santa Maria. 20. Elsmere Cañon. 21. Santa Paula. 22. Ventura. 23. Los Angeles. 24. Puente Hills. 25. San Diego. 26. Carrizo Creek or Coyote Mountain.

After Merriam, 1917, fig. 1, p. 199.

Fig. 11. Pliocene exposures in California. Supplementary to Fig. 12.

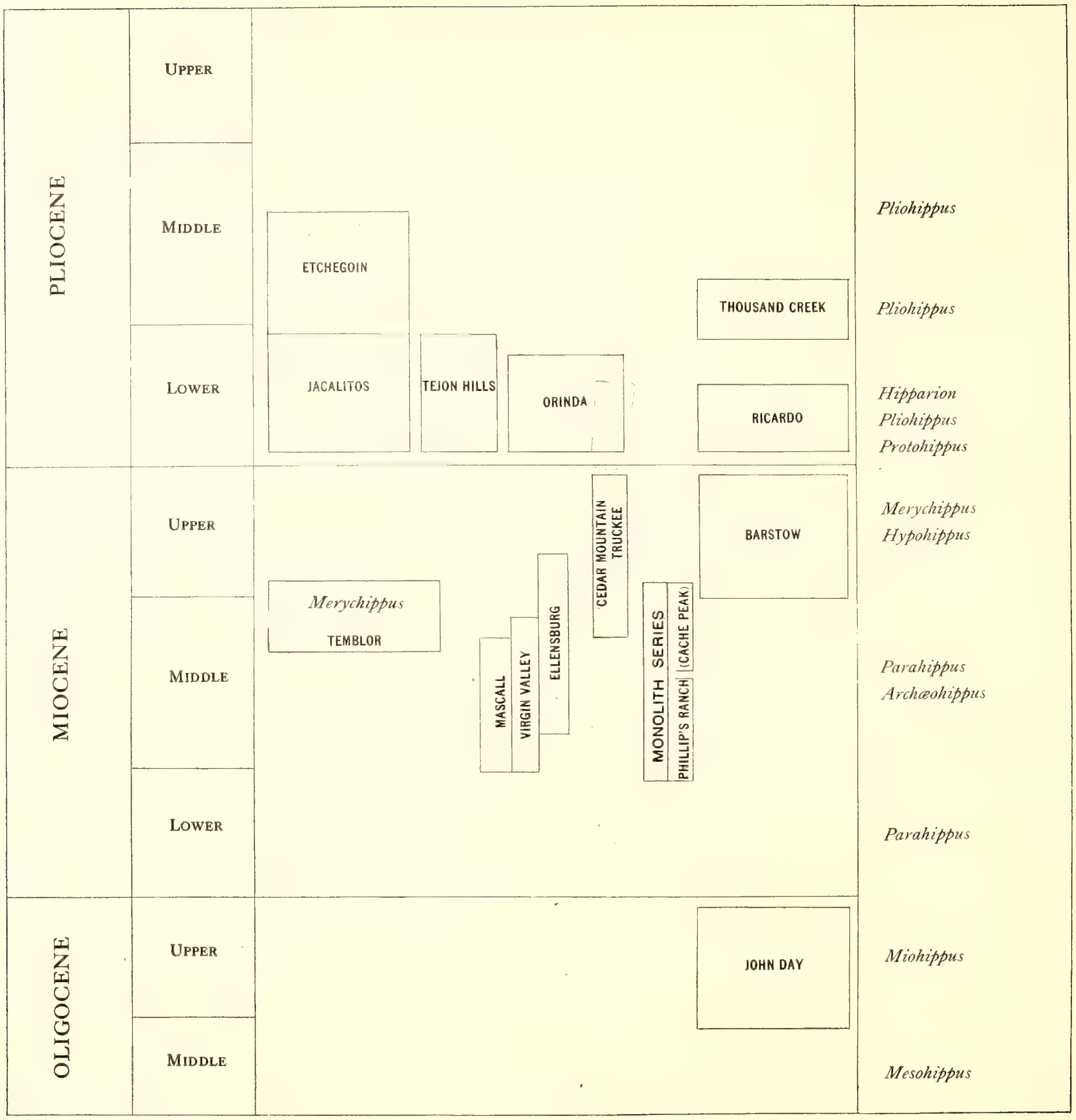


Fig. 12. Approximate Correlation of formations containing University of California types of Pacific Coast and Great Basin Horses. By John C. Merriam, October, 1915.

	Geologic occurrence of type specimens or important figured specimens of Pacific Coast and Great Basin Horses in the University of California collections.
	Genus, Species, Locality.
Pliocene	*Hipparion gidleyi*—Petaluma *Hipparion leptode*—Thousand Creek *Hipparion molle*—Jacalitos *Hipparion platystyle*—Orinda *Hipparion mohavense callodonte*—Ricardo *Hipparion mohavense*—Ricardo *Pliohippus proversus*—Etchegoin *Pliohippus coalingensis*—Etchegoin *Pliohippus fairbanksi*—Ricardo *Pliohippus tantalus*—Ricardo *Protohippus tehonensis*—Tejon Hills
Miocene	*Hipparion condoni*—Ellensburg *Merychippus intermontanus*—Barstow *Merychippus calamarius* — Barstow *Merychippus sumani*—Barstow *Hypohippus (Drymohippus) nevadensis*—Esmeralda *Merychippus californicus*—Temblor *Parahippus*, near *avus*—Virgin Valley *Archæohippus ultimus*—Mascall
Oligocene	*Miohippus acutidens* — Upper John Day

Distribution of Species of the *Hipparion* Group in the Sonoran Region, West of the Wasatch Range.

	Miocene to Pliocene		Pliocene					
	Ellensburg, Wash.	Ricardo, Calif.	Orinda, Calif.	Tejon Hills, Calif.	Jacalitos, Calif.	Rattlesnake, Ore.	Thousand Creek, Nev.	Petaluma, Calif.
Hipparion sinclairi	...	...	...	...	...	×		
Hipparion occidentale	...	...	...	...	...	?		
Hipparion condoni	×							
Hipparion mohavense	...	×	?					
Hipparion mohavense callodonte	...	×						
Hipparion platystyle	...	?	×					
Hipparion molle	...	...	...	×	×			
Hipparion leptode	...	...	...	...	...	...	×	
Hipparion gidleyi	...	...	...	...	...	...	...	×

Snake Creek, Sioux County, Western Nebraska (Lower Pockets).

As described by Matthew, Cook (1909), and Sinclair (1915) these deposits contain a more ancient *Parahippus, Merychippus, Hypohippus* horse fauna of Upper Miocene age, also a more modern *Protohippus, Pliohippus, Hipparion* fauna of Lower Pliocene age, as well as *Pliauchenia* and *Peraceras*. See p. 28 below.

Geologic Age of "Temblor" (Anderson, 1908), or Vaqueros.

North Coalinga, Kings County, So. Cal., Merriam, 1915.

Marine deposit, twelve miles north of Coalinga, California.

The vertebrate collection representing the *Merychippus* fauna was obtained in a zone at the upper limit of the "Temblor," as explored by the University of California in 1913 (Moody and Douglass). The Merychippus zone yielded here teeth of the Sirenian *Desmostylus ?hesperus,* and other marine forms, including *Carcharodon*. The fauna washed in from the adjacent land included the type of *Merychippus californicus* Merriam, also mammalian teeth referred to *Prosthennops, Procamelus, Tetrabelodon*. It is probable that the Temblor containing the *Turritella ocoyana* fauna is synchronous with the marine Monterey, which by some invertebrate palæontologists (James Perrin Smith) is regarded as Oligocene or Lower Miocene. Merriam (*Trans. Am. Philos. Soc.*, 1915) observes, however, that the Temblor cannot be earlier than Middle Miocene because neither *Merychippus* nor Proboscidea are known earlier than the Middle Miocene.

As described by Merriam this phase contains the type of *Merychippus californicus,* progressive species, indicating a late phase of the Merychippus zone, all the genera occurring here. This is a marine littoral deposit, associated with an invertebrate fauna referred to the marine Lower Miocene, and includes the Sirenian *Desmostylus ?hesperus* and the shark *Carcharodon,* also the land mammals *Tetrabelodon, Procamelus, Prosthenops.*

Type of *Merychippus californicus* Merriam. 1915.1.

Bijou Hills, Brule County, South Dakota, Leidy, 1854.

According to Matthew this is probably an outlyer of the beds north and east of Valentine, Niobrara River, Nebraska. Beside the indecisive type of *Merycodus necatus* Leidy the following types have been described from this locality.

Type of *Hippodon speciosus* Leidy, 1854. Type of *Merychippus insignis* Leidy, 1857.

Procamelus-Hipparion Zone, Upper Miocene or Lower Pliocene. Pontian Stage of Europe.

The type region of this very prolonged and important period of geologic deposition is along the Niobrara and Little White Rivers of western Nebraska and South Dakota, as explored by Hayden in 1857.

1. Horizon F of Hayden and Leidy, 1869, the "Loup Fork" of Hayden (lower portion only).
    1*a*. Niobrara River localities, Hayden, Leidy, Gidley.
    1*b*. Little White River localities, Hayden, Leidy, Gidley.
2. "Loup Fork," Cope, Scott and Osborn in part, 1877–1894.
3. Nebraska formation, Cosoryx (= Merycodus) beds, western Nebraska, Scott, 1894.
4. Ogallala formation in part, western Nebraska, Darton, 1899.
5. Niobrara formation, King, 1878 (preoccupied, Cretaceous).
7. Procamelus beds (= upper "Loup Fork"), Cope, 1883.
8. Pliohippus beds, Marsh, 1896.
11. Protohippus zone, Osborn, 1907.
15. Valentine beds, Barbour, Cook, 1917. Near Ft. Niobrara.
18. Fort Niobrara formation, Osborn, 1918. Type locality on Niobrara River, near Fort Niobrara.
16. Oak Creek formation, Troxell, 1916, near Mission, So. Dakota.

PLIOCENE MAMMAL FAUNAS OF PACIFIC COAST AND GREAT BASIN

	PACIFIC COAST PROVINCE				GREAT BASIN PROVINCE				
	SAN FRANCISCO BAY		*NORTH COALINGA*	*TEJON HILLS*	*MOHAVE*	*MIDDLE BASIN*	*JOHN DAY*	*IDAHO*	*EASTERN WASHINGTON*
PLEISTOCENE	MERCED?	RODEO			MANIX	LAHONTAN	TERRACES	IDAHO *Equus*	WHITE BLUFFS *Equus*
PLIOCENE	MERCED SONOMA TUFF *Neohipparion*	ORINDA PINOLE TUFF *P. coalingensis* *P. fairbanksi* *Ilingoceros*	TULARE *Hyaenognathus* ETCHEGOIN *P. proversus Zone* *P. coalingensis Zone* *Neohipparion Zone*	CHANAC *Hipparion* *Merycodus*	RICARDO *Hipparion* *Merycodus* *Oreodont*	THOUSAND CREEK *Neohipparion* *Teleoceras* *Sphenophalos* *Ilingoceros*	RATTLESNAKE *Neohipparion* *Teleoceras* *Sphenophalos* *Indarctos*		
MIOCENE	SAN PABLO		SAN PABLO [SANTA MARGARITA] TEMBLOR *Merychippus* *Procamelus* *Tetrabelodon*	SAN PABLO [SANTA MARGARITA]	BARSTOW *Merychippus* *Dromomeryx* PHILLIPS RANCH *Primitive Merychippus*	VIRGIN VALLEY *Merychippus* *Merycodus* *Dromomeryx* *Merychyus* CANYON RHYOLITE	MASCALL *Merychippus* *Parahippus* *Dromomeryx* COLUMBIA LAVA		ELLENSBURG *Hipparion* *MASCALL FLORA* YAKIMA BASALT

Fig. 13. Most recent correlation of the chief California, Nevada, and Oregon fossil-bearing localities. John C. Merriam, 1916.

6. Santa Fé Marls, New Mexico, Cope, 1877.
9. Clarendon beds, Llano Estacado, northwestern Texas, Gidley, 1903.
10. Madison Valley beds, western Montana, Douglass, 1899.
12. Upper Pawnee Creek, northwestern Colorado, Matthew, 1913.
13. Ellensburg, Washington, Merriam, 1915.
14. Devil's Gulch (lower beds), Niobrara River, about forty miles east of Fort Niobrara, Barbour, 1914.
17. Esmeralda, Nevada, Merriam.

FORT NIOBRARA, NIOBRARA RIVER, NEBRASKA.

This is the "Horizon F" of Hayden and Leidy (1869); it is the lower portion of the "Loup Fork" of Hayden. The type of *Hypohippus* (*Anchitherium*) *affinis* was collected here during the exploration of 1857. During the same year the type of *Parahippus* (*Anchitherium*) *cognatus* was recorded, namely, "Upper Niobrara River near Fort Niobrara;" also the type of *Protohippus* (*Equus*) *perditus* and the type of *Protohippus placidus*. In 1857 Hayden collected here also the type of *Merychippus mirabilis* Leidy, since referred to *Pliohippus mirabilis*. To the Niobrara River Leidy (1869) attributed his type of *Hipparion affine*. In 1873 Clifford and Marsh collected from a locality further west or up the river, probably above the mouth of Snake River, the type of *Pliohippus pernix* Marsh, also in the same year the type of *Pliohippus robustus* Marsh. In 1906 Gidley collected the type of *Protohippus niobrarensis* from near Fort Niobrara.

Type of *Hypohippus affinis* Leidy, 1858.
" " *Parahippus cognatus* Leidy, 1858.
" " *Protohippus perditus* Leidy, 1858.
" " " *placidus* Leidy, 1869.
" " " *niobrarensis* Gidley, 1906.2.

Type of *Pliohippus mirabilis* Leidy, 1858.
" " " *pernix* Marsh, 1874.1.
" " " *robustus* Marsh, 1874.2.
" " *?Hipparion affine*[1] Leidy, 1869.1.

LITTLE WHITE RIVER, SOUTH DAKOTA.

In 1866 Hayden discovered on the Little White River of South Dakota the type of *Pliohippus supremus* Leidy. In 1905 Gidley collected here his type of *Protohippus simus*. In 1856 Hayden collected here the type of *Hipparion occidentale* Leidy. To the Little White River Leidy (1869) attributed the type of *Hipparion gratum*. On the Little White River Gidley (1905) secured his neotype of *Hipparion gratum*. In 1902 Wells and Gidley collected the type of *Hipparion whitneyi*. In 1903 Gidley collected at Big Spring Cañon, Little White River, the type of *Hipparion dolichops*.

Thus from the Little White River neither *Merychippus* nor *Parahippus* has been recorded. *Hypohippus* is represented only by some teeth found by Matthew at Big Spring Cañon, a locality where admixture is not wholly excluded.

Type of *Protohippus simus* Gidley, 1906.1.
" " *Pliohippus supremus* Leidy, 1869.
" " *Hipparion occidentale* Leidy, 1856.
" " *Pliohippus lullianus* Troxell, 1916.2.

Type of *Hipparion gratum* Leidy, 1869.2.
" " " *whitneyi* Gidley, 1903.
" " " *dolichops* Gidley, 1906.

CHANAC FORMATION, BUWALDA, 1915.

Tejon Hills, San Joaquin Valley, Southern California.

Of nearly the same Lower Pliocene or latest Miocene age as the lower portion of the Jacalitos Etchegoin of the North Coalinga region and the Ricardo stage of the Mohave area (Merriam, 1916, *op. cit.*, pp. 116, 117). It includes:

Type of *Protohippus tehonensis* Merriam, 1915.

Type of *Hipparion* (*Neohipparion*) *gratum tehonense* Merriam, 1916.3.

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[1] It is possible that *Hipparion affine* was derived from a younger zone (J. C. M. 1917).

Clarendon Beds, Llano Estacado, Texas, Gidley, 1903.

Including Palo Duro Cañon, Mulberry Cañon, localities of Cummins and of Cope.

These beds contain *Procamelus, Pliauchenia, Trilophodon productus, ?Teleoceras, Dinocyon,* equines referred to *Hipparion occidentale* and *Protohippus ?perditus.* It is significant that no *Merychippus* has been recorded here. The important equine types described from this region by Cope are the following:

Type of *Pliohippus* (= *Protohippus*) *fossulatus* Cope, 1893.1.
Type of *Protohippus pachyops* Cope, 1893.
" " *Pliohippus* (*Hippidium*) *interpolatus* Cope, 1893.2.
Type of *Hipparion* (*Protohippus*) *lenticulare,* Cope, 1893.1.
Type of *Hipparion* (*Equus*) *eurystyle* Cope, 1893.2.

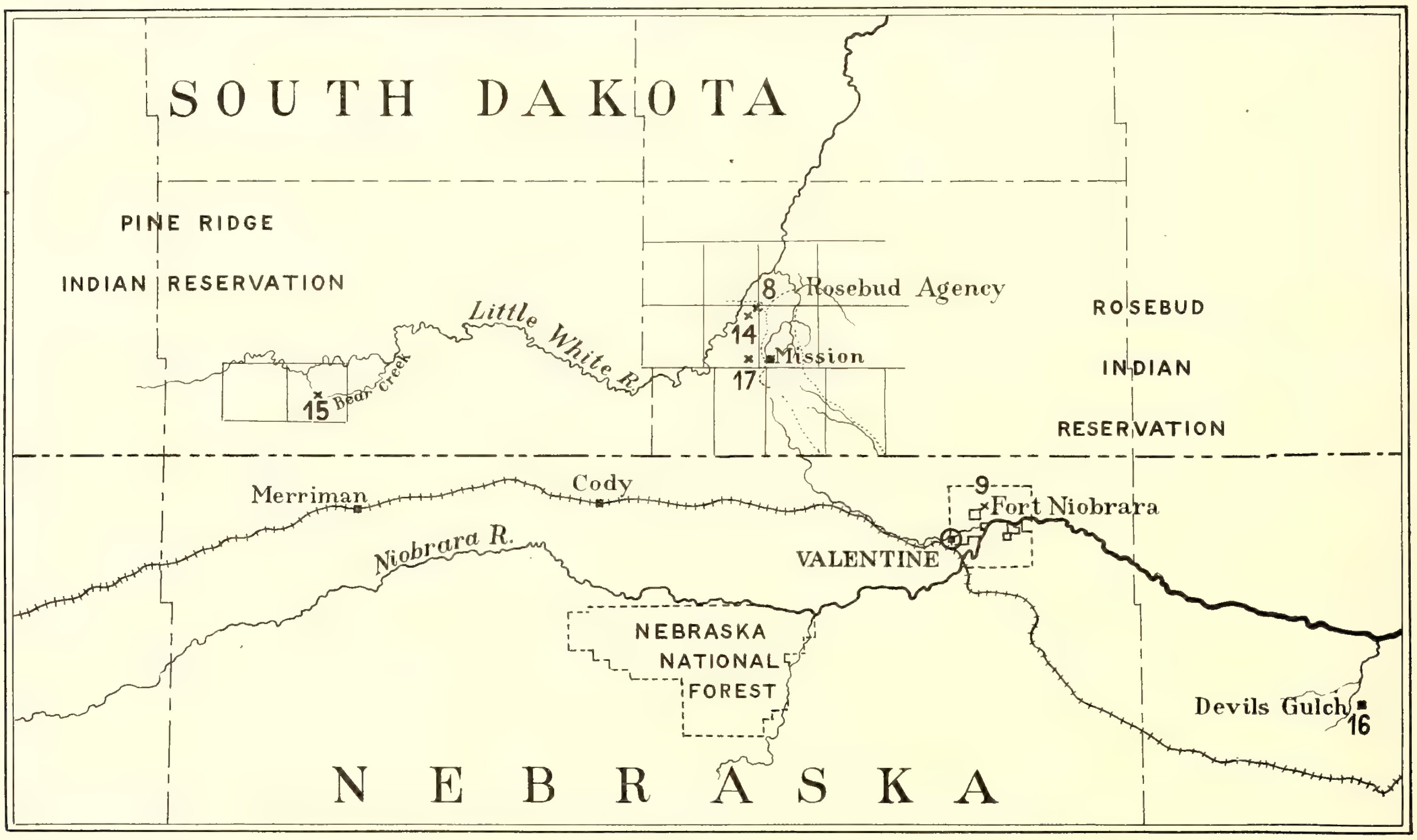


Fig. 14. Exposures of the Procamelus-Hipparion zone, Lower Pliocene.
Outline map showing the localities on the Niobrara River, Nebraska, and Little White River, South Dakota, where Leidy, Gidley, and Troxell secured some of their chief equine types, including: 8 ? *Protohippus simus,* 9 *Protohippus niobrarensis,* 14 *Hipparion whitneyi,* 15 *Hipparion dolichops,* 16 *Protohippus* ? sp., 17 *Pliohippus lullianus.*

Orinda and Siestan, Central California.

Of Early Pliocene age, (Merriam, 1917), occurring in the hills immediately east of Berkeley, middle California.

This horizon contains remains of *Procamelus, Pliauchenia, ?Merychippus, Protohippus,* and *Hipparion,* including:

Type of *Hipparion platystyle* Merriam, 1915.4.

Upper Pawnee Creek, Northeastern Colorado, Matthew, 1913.

The species of horses of the Upper Pawnee Creek beds (see p. 19), Sand Cañon, as observed by Matthew are to be compared with those of the Procamelus-Hipparion zone, both in the milk and permanent teeth. They appear to possess the full generic characters of *Protohippus* and *Hipparion.*

Type of *Protohippus proplacidus* Osborn, 1918.

Esmeralda, Nevada, Turner, Merriam, 1916.

From this horizon camels (*Procamelus, Pliauchenia*) are abundant, *Merycodus furcatus* occurs, horses are rare (*Merychippus, Hypohippus ?osborni*).

The Mina locality, a station originally known as the Cedar Mountain beds, contains an exposure which is evidently an extension of the Esmeralda formation (Merriam, letter Sept. 15, 1917).

The Cedar Mountain sediments are correlated in age with the Esmeralda of the Silver Peak region (Turner), also with the Truckee beds of King (Merriam, 1916, p. 167).

Ellensburg, Washington, Merriam, 1915.

"It seems that the Ellensburg formation may be of considerably later date than the beds containing the typical Mascall fauna of eastern Oregon." (Merriam, 1915). "It apparently equals the Mascall below and a later horizon containing *Hipparion* in upper part of the section." (Merriam, 1916). This horizon yields:

Type of *Hipparion condoni* Merriam, 1915.5.

Note: The *H. condoni* occurs in a zone in the upper part of the section, several hundred feet above the Mascall flora (Merriam, 1916).

Madison Valley, Montana, Douglass, 1899.

Described by Douglass as twenty miles south from the Three Forks of the west side of the Missouri River, perpendicular cliffs composed of clays, fine sands, volcanic ash, and conglomerate, containing referred specimens of *Protohippus, Hipparion, Merychippus, Procamelus, Cosoryx,* etc. The type of *Parahippus* (*Anchitherium*) *minimus* is attributed to the Madison Valley beds in all of Douglass's references to this species.

Type of ?*Parahippus* (*Anchitherium*) *minimus* Douglass, 1899.

Flint Creek, Montana, Douglass, 1903.

Bluffs 100–120 feet in thickness in the valley of the Flint Creek, Montana. Explored by Douglass in 1899. Contain referred *Protohippus* and *Procamelus.* The age of these beds is not fully determined.

PERACERAS-PLIAUCHENIA ZONE, LOWER PLIOCENE. PONTIAN, EPPELSHEIM, PIKERMI, IN PART.

The Republican River beds, along the river of the same name in northwestern Kansas, contain very advanced forms of rhinoceros (*Peraceras*) and of mastodon (*Tetrabelodon campester*). They constitute the type formation of the Peraceras zone of Osborn.

1. Republican River, upper "Loup Fork," northwestern Kansas, Cope.
2. Ogallala formation (typical), southwestern Nebraska, Darton, 1899.
3. Alachua Clays, Archer beds, Florida, Dall, 1892.
4. Snake Creek beds (in part), western Nebraska, Matthew, Cook, 1909.
5. Petaluma, California, ?lower Ricardo, Cal., Merriam.
6. ?Devil's Gulch (upper beds), Niobrara River, Nebr., Barbour.

Republican River, Northwestern Kansas, 100 feet.

This horizon contains the advanced rhinoceros *Peraceras*, also *Procamelus*, and a small form of *Pliauchenia*. It includes abundant remains of *Pliohippus*, *Protohippus*, *Hipparion*, *Hypohippus*, and a number of large and specialized surviving forms of *Merychippus*, as follows:

Type of *Merychippus republicanus* Osborn, 1918.9.
“ “ “ *patruus* Osborn, 1918.10.
“ “ *Protohippus retrusus* Cope, 1889.1.
Type of *Protohippus profectus* Cope, 1889.2.
“ “ *Pliohippus nobilis* Osborn, 1918.1.

Snake Creek, Sioux County, Western Nebraska, Matthew, Cook, 1909, Whitford, Matthew, 1916.

It is remarkable in yielding stages of the Equidæ, which are divided by Matthew into two faunal zone groups. This faunal zone grouping may subsequently be found to conform with a geologic grouping, as below:

1. *Fauna of the Merychippus Pockets.*

It is not positively shown that *Merychippus*, *Parahippus*, and *Hypohippus* occur in the pockets containing *Protohippus*, *Hipparion*, and *Pliohippus*.

1. *Merychippus* cf. *insignis* Leidy. Palates, jaws, teeth, very abundant.
   Diagnosis: — Size small, teeth brachyodont, enamel of lake borders moderately infolded, protocone separate nearly to base, round oval with antero-external fold. Premolar 2 short antero-posteriorly. Lachrymal fossa well defined, not close to orbit. No malar fossa. Feet tridactyl, rather short, slender.
   Near to *M. seversus*.
   Smaller than *M. sphenodus*, teeth shorter, p^2 shorter antero-posteriorly.
2. *Merychippus* cf. *calamarius*. Palates, jaws, and teeth very abundant.
   Diagnosis: — Related to the above but larger and with longer crowned teeth, p^2 of normal proportions.
3. *Merychippus ?calamarius propinquus*. Equally abundant, with No. 2.
   Diagnosis: — Intermediate between No. 1 and No. 2.
4. *Merychippus ?insignis obliquus*, subspec. indesc. A few teeth.
   Diagnosis: — Near to No. 1 but prefossette open or imperfectly closed.
5. *Hypohippus* cf. *affinis* Leidy. teeth and jaw fragments.
6. *Hypohippus pertinax* sp. indesc. parts of jaws and teeth.
   Diagnosis: — Size of *H. equinus* Scott, equally brachyodont but p_1 minute, vestigial (well developed in *P. equinus*), and heel of m_3 more reduced, p_2 slightly broader.
7. *Parahippus* cf. *cognatus* Leidy. Parts of jaws and teeth.

2. *Fauna Partly or Wholly from Later Pockets.*

Occurrence of *Merychippus* in these pockets is uncertain; they are probably not all of same age.

1. *Protohippus* cf. *perditus* Leidy. Teeth and jaw fragments.
2. “ cf. *simus* Gidley. “ “ “ “
3. “ cf. *placidus* Leidy. “ “ “ “
   Diagnosis: — Many of the teeth referred to here have much longer crowns and smaller in cross section than the type.
4. *Hipparion* cf. *gratum* Leidy. Teeth and jaw fragments.
   Diagnosis: — Many of the teeth referred to here are much longer-crowned and smaller in cross section. They are separable with difficulty from corresponding variants of *P. perditus*.
5. *Hipparion* cf. *occidentale* Leidy. Teeth and jaw fragments.
   “ “ *sodalis*, subspec. indesc.
   Diagnosis: — Smaller than *H. occidentale*, protocone flattened oval at base, round oval toward tip. Complexity of enamel folding variable, usually less than in *H. occidentale*, only rarely so simple as in *H. whitneyi*. Teeth and jaw fragments very abundant.
6. *Pliohippus* cf. *mirabilis* Leidy. Numerous teeth and jaw fragments referable to the group, including *mirabilis*, *supremus*, *pernix*, and *robustus*.
7. *Pliohippus* cf. *spectans* Cope. Many teeth and jaw fragments referable to the group including *spectans*, *interpolatus*, *lullianus*, etc.

3. *Fauna from Upper Pocket Levels.*

8. Type of *Pliohippus leidyanus* Osborn.

Alachua Clays, Archer Beds, Florida.

This horizon, which may be composite, or of both older and more recent date, namely, of *Procamelus-Hipparion* age, contains (?) *Teleoceras proterus* Leidy. In addition to two referred specimens of *Hipparion minor* the Alachua formation has yielded two equine types, as follows:

Type of *Hipparion ingenuum* Leidy, 1885.1.
Type of *Hipparion plicatile* Leidy, 1887.

The *H. plicatile* is a highly progressive species.

Bone Valley Formation, Florida, Sellards.

The type locality of this formation is Brewster, Polk County, Florida, which yields the type of *Hipparion minor* Sellards. It is probable that the Bone Valley formation is contemporaneous with the Alachua Clays, Florida.

Type of *Hipparion minor* Sellards, 1916.1.

Petaluma, California, Merriam.

Type of *Hipparion gidleyi* Merriam, 1915.1.

Age of Devil's Gulch, Niobrara River, Nebraska.

Including lower and upper beds.

Lower levels. These exposures on the south side of the Niobrara River, twenty miles east of Fort Niobrara, as reported by Barbour, Whitford, and Matthew, compare on the *lower levels* with the fauna of the Procamelus zone. The types of Proboscidea discovered here by Barbour, namely, *Tetrabelodon willistoni* and *Eubelodon morrilli* are much more primitive than the *T. campester* of the Republican River. The lower levels contain also specimens referred to *Merychippus.*

Upper Levels. As described by Barbour (June 10, 1914) the [upper] fauna is regarded (Matthew) as of the age of the Snake Creek or slightly more recent, and the upper levels contain a somewhat more recent fauna than the lower. The upper fauna is reported to include a variety of camels, *Alticamelus, Procamelus, Pliauchenia,* also *Eubelodon morrilli,* among oreodonts *Metoreodon,* among horses *Protohippus, Pliohippus, Hipparion.* The new horse recorded here, *Hypohippus matthewi* Barbour is somewhat near *H. affinis* Leidy.

Type of *Hypohippus matthewi* Barbour, 1914.

Pliohippus-Pliauchenia Zone, Second Phase of Lower Pliocene.

This phase is distinguished by the absence of *Hypohippus, Merychippus, Protohippus,* by the disappearance of the rhinoceroses, and by the abundance of *Pliohippus* of advanced type and of *Hipparion.*

1. Ricardo, Southern California, bordering the Mohave Desert, Merriam, Buwalda, 1912, 1914.
2. Rattlesnake, Ore., Merriam, Sinclair, 1901, 1907.
3. Jacalitos, California, Merriam, 1915.
4. Pinole Tuff, San Pablo Bay, Cal., Merriam, 1913.
5. Orinda, resting upon Pinole Tuff, San Pablo Bay, Cal. (Merriam, letter Sept. 15, 1917).

Ricardo, El Paso Range, Southern California.

Lower and Upper Levels, Merriam, 1912, 1914.

The lower Ricardo fauna is still incompletely known. The upper Ricardo, 3,000 and 3,500 feet, is regarded by Merriam as slightly more recent than Snake Creek. It contains no *Merychippus.* The other equines are regarded by Matthew as less progressive than certain Snake Creek forms. *Hipparion* is abundant, also *Pliohippus.*

Type of *Pliohippus tantalus* Merriam, 1913.
" " " *fairbanksi* Merriam, 1915.

Type of *Hipparion mohavense* Merriam, 1913.
" " " " *callodonte* Merriam, 1915.6.

Pinole Tuff Formation, San Pablo Bay, California, Merriam 1913.

This formation contains a great number of vertebrate remains, including horses of the *Pliohippus* type near *Pliohippus fairbanksi* of the Ricardo Pliocene. This Pinole species is also very close to the *Pliohippus* species of the Rattlesnake Pliocene. The Pinole Tuff belongs in the lower portion of the Pliocene.

ORINDA, SAN PABLO BAY, CALIFORNIA, MERRIAM, 1913.

The Orinda formation rests upon the Pinole Tuff fauna, which includes an *Hipparion* species near *H. mohavense* of the Ricardo (Merriam, letter Sept. 15, 1917).

JACALITOS, NORTH COALINGA REGION, CALIFORNIA, MERRIAM, 1915.

Within the limits of the beds mapped as *Jacalitos* (Arnold Anderson, 1910) remains of *Pliohippus* have been found. *Hipparion* occurs only in the lowest levels as described by Merriam (*Trans. Am. Philos. Soc.*, 1915, p. 216).

Regarded by Merriam as lower Middle Pliocene.

Type of *Hipparion molle* Merriam, 1915.2.

RATTLESNAKE, JOHN DAY BASIN, OREGON.

The type of *Platygonus rex* Marsh is recorded from Wilson Springs, Crooked River, south of John Day Valley, Ore. (J. C. M.). Among the referred specimens are *Pliohippus supremus* Leidy, also the type of *Alticamelus altus.*

Type of *Pliohippus* (*Hippidium*) *spectans* Cope, 1880.

Type of *Hipparion* (*Hippotherium*) *sinclairi* Wortman, 1882.

ILINGOCERAS ZONE, MERRIAM, 1909.

Typified by the fauna of Thousand Creek, Nevada, called lower Middle Pliocene.

THOUSAND CREEK, NEVADA.

This horizon is regarded by Merriam and Matthew as more recent than Snake Creek, Ricardo, or nearer Rattlesnake (Merriam, 1916), as earlier than Blanco. Its characteristic strepsicerine antelopes are *Ilingoceras, Sphenophalus.* A rhinoceros related to *Teleoceras* recorded here may give this horizon an earlier date. Beside its referred *Pliohippus fairbanksi* is found the

Type of *Hipparion leptode* Merriam, 1915.3.

PLIOHIPPUS COALINGENSIS ZONE.

LOWER ETCHEGOIN, NORTH COALINGA REGION, CALIFORNIA, MERRIAM, 1915.

Merriam observes (*Trans. Am. Philos. Soc.*, 1915, p. 193) that the lower Etchegoin horizon is characterized by the presence of *Pliohippus coalingensis* and may be known as the *Pliohippus coalingensis* zone. This faunal zone near the base of the Etchegoin in the North Coalinga region represents a distinctly more advanced stage than that of the Jacalitos, according to Merriam. It yields the

Type of *Pliohippus* (*Protohippus*) *coalingensis* Merriam, 1914.

GLYPTOTHERIUM ZONE, MIDDLE PLIOCENE. ASTIAN STAGE OF EUROPE.

This well defined life stage is typified by the fauna of the Blanco formation, Llano Estacado, Texas, containing *Glyptotherium, Megalonyx, Pliauchenia, Platygonus,* and *Dibelodon mirificus.* This zone is probably later than the Lower Etchegoin of North Coalinga (Merriam, 1916). The important equine types are progressive forms of *Pliohippus,* three of which were originally referred to *Equus* by Cope, as follows:

Type of *Pliohippus* (*Equus*) *cumminsii* Cope, 1893.3.
" " " (*Equus*) *minutus* Cope, 1893.4.

Type of *Pliohippus* (*Equus*) *simplicidens* Cope, 1892.

Pliohippus proversus Zone.

Upper Etchegoin, North Coalinga Region, Merriam, 1915.

The Upper Etchegoin, which was fully described by Merriam in 1915 (*Trans. Amer. Philos. Soc.*, 1915, p. 222), is a formation of considerable thickness, containing an advanced vertebrate mammalian fauna, the species of which are relatively close to those of the Pleistocene of Rancho La Brea; yet this Upper Etchegoin formation lies below the Tulare formation, 3,000 feet in thickness, which is regarded as of Upper Pliocene age. The Tulare is almost exclusively fresh-water; it includes a thin marine phase near the upper limit (Merriam, 1917).

The feature of this horizon is the presence of camels near *Camelops* or *Pliauchenia*, also of cervids resembling *Odocoileus*. Most distinctive also is the *Pliohippus proversus* Merriam, a horse almost as advanced as the *Equus excelsus* of Leidy. *Hyænognathus* is evidently from this Tulare formation above the Upper Etchegoin (Merriam, 1917).

Type of *Pliohippus proversus* Merriam, 1916.1.

Tulare Formation, North Coalinga Region, California.

The Tulare rests above the Upper Etchegoin *Pliohippus proversus* beds of the North Coalinga Region in California. It contains a large feline described as *Machærodus ischyrus* (Merriam, 1917).

Idaho Formation, southwest Idaho, Cope, 1883.

Described by Cope in 1883, without giving type locality or type section. From these beds Cope described twenty-three species of fishes, representing eight genera. Mammalian remains from beds presumed to represent Idaho include a referred (Leidy) *Mastodon mirificus* and a referred *Equus excelsus*. In 1916 Merriam and Buwalda obtained from beds representing the Idaho formation the type of *Equus idahoensis* and a sabre-tooth resembling *?Machærodus ischyrus*. The Idaho is at present referred to a stage near that of the Tulare formation, which rests upon the *Pliohippus proversus* phase of the Upper Etchegoin of the North Coalinga region in California (Merriam, letter Sept. 15, 1917).

Type of *Equus idahoensis*, Merriam.

Tehuichila, Vera Cruz, Hidalgo, Mexico, Cope, 1885.

See also Tehuichila and Lacualtipan, Mexico. Later than Barstow and Santa Fé (Merriam, 1917).

Type of *Hipparion montezuma* Leidy, 1883.
" " " *peninsulatum* Cope, 1885.2.
Type of *Hipparion rectidens* Cope, 1886.
" " *?Protohippus castilli* Cope, 1885.

Ashley River, South Carolina.

A Lower Pleistocene composite fauna. Here occurs also, probably through redeposition, a Pliocene species, the

Type of *Hipparion venustum* Leidy, 1859.

Peace Creek, Florida.

Here occurs, also probably through redeposition, the Pliocene equine

Type of *Hipparion princeps* Leidy, 1890, = *Equus ?fraternus* Leidy, 1860, *auct* Gidley.

Elephas imperator-Equus excelsus Zone, Lower Pleistocene. Sicilian, Cromerian, or St. Prestian of Europe.

The E. imperator zone (Osborn, 1909) does not appear to be distinguished from the Equus beds (Cope), Lower Pleistocene (W. D. M., 1916).

1. Typical Loup River beds, Loup Fork of Platte, Meek and Hayden, 1861, 1862.
    2. Horizon F (upper part only), Hayden and Leidy, 1869.
    4. Equus (*E. excelsus*) beds, Cope.
    5. Sheridan beds, Scott.
3. Several formations (unnamed) in Texas and Mexico, containing *Elephas imperator.*
6. Elephas imperator zone, Osborn, 1909.

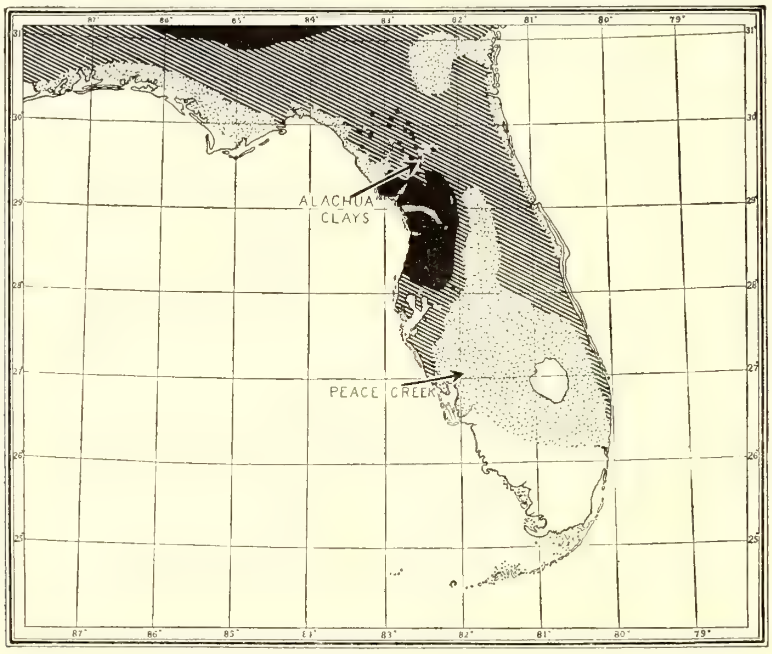
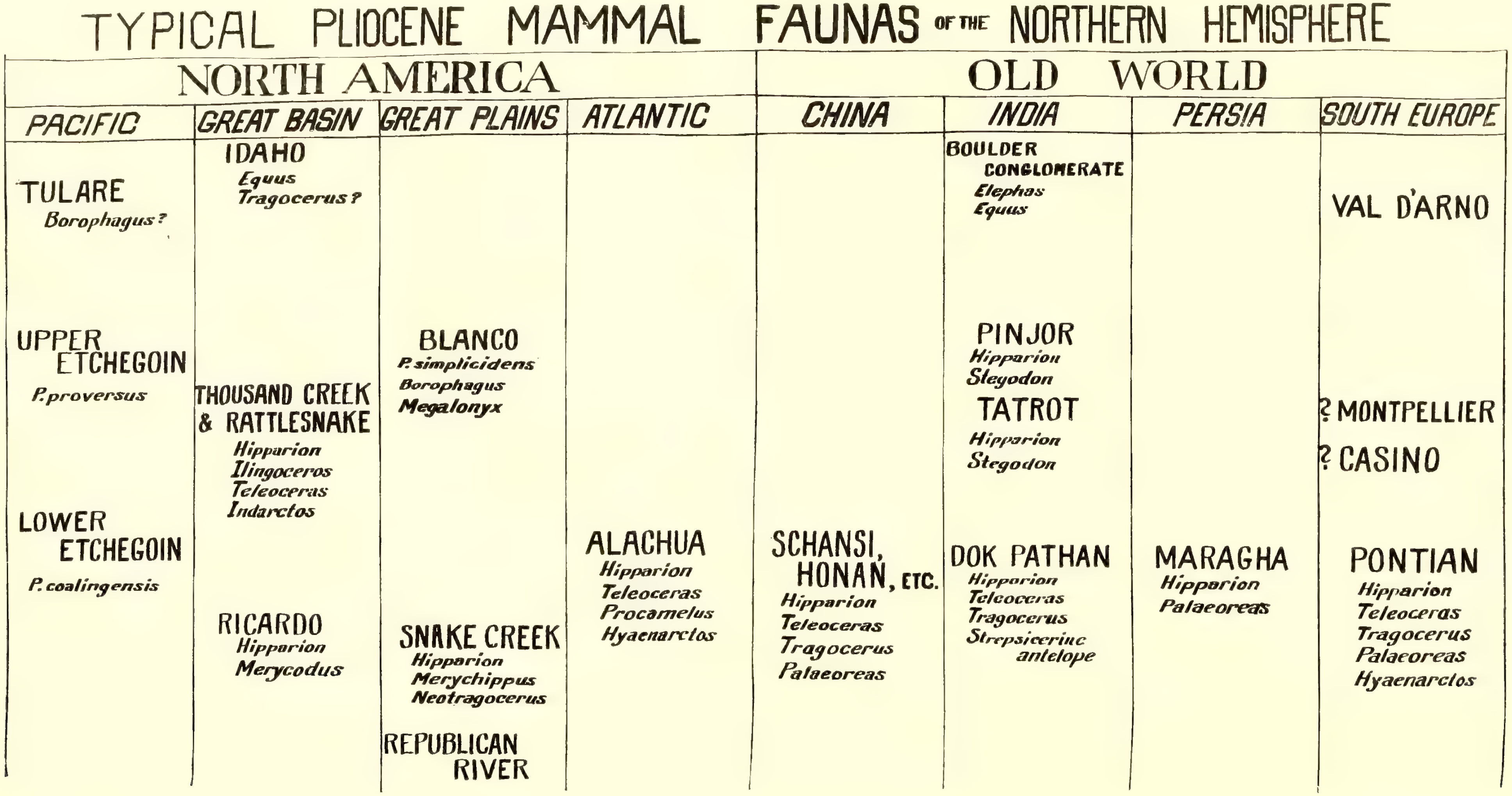


Fig. 15. Regions of the Alachua Clays (Lower Pliocene) and Peace Creek (Upper Pliocene) deposits of Florida. After Osborn, 1910.

Of the specimens collected in the typical Loup River beds Leidy recorded in 1869 the following: *Elephas imperator Mastodon* (*Dibelodon*) *mirificus*, *Equus excelsus*. The type of *Equus excelsus* is elsewhere stated to be from the "Pawnee Loup branch of the Platte or Niobrara River." This indicates a slightly different faunal phase than that of the typical Equus beds or zone of Cope. The *E. excelsus* type of Leidy is slightly similar in crown pattern to Merriam's *Pliohippus proversus* of the Upper Etchegoin.

Type of *Equus excelsus* Leidy, 1858.



TYPICAL PLIOCENE MAMMAL FAUNAS OF THE NORTHERN HEMISPHERE

NORTH AMERICA				OLD WORLD			
PACIFIC	GREAT BASIN	GREAT PLAINS	ATLANTIC	CHINA	INDIA	PERSIA	SOUTH EUROPE
TULARE *Borophagus?*	IDAHO *Equus* *Tragocerus?*				BOULDER CONGLOMERATE *Elephas* *Equus*		VAL D'ARNO
UPPER ETCHEGOIN *P. proversus*	THOUSAND CREEK & RATTLESNAKE *Hipparion* *Ilingoceros* *Teleoceras* *Indarctos*	BLANCO *P. simplicidens* *Borophagus* *Megalonyx*			PINJOR *Hipparion* *Stegodon* TATROT *Hipparion* *Stegodon*		? MONTPELLIER ? CASINO
LOWER ETCHEGOIN *P. coalingensis*	RICARDO *Hipparion* *Merycodus*	SNAKE CREEK *Hipparion* *Merychippus* *Neotragocerus* REPUBLICAN RIVER	ALACHUA *Hipparion* *Teleoceras* *Procamelus* *Hyaenarctos*	SCHANSI, HONAN, ETC. *Hipparion* *Teleoceras* *Tragocerus* *Palaeoreas*	DOK PATHAN *Hipparion* *Teleoceras* *Tragocerus* *Strepsicerine antelope*	MARAGHA *Hipparion* *Palaeoreas*	PONTIAN *Hipparion* *Teleoceras* *Tragocerus* *Palaeoreas* *Hyaenarctos*

Fig. 16. Most recent Pliocene correlation of the New and Old Worlds. After John C. Merriam, 1916.

PRELIMINARY KEY TO THE GEOLOGIC DISTRIBUTION OF THE PRINCIPAL SPECIES OF EQUIDÆ.

PLEISTOCENE	Lower	19. Equus Excelsus-Elephas Imperator Zone		
		Loup River, Typical	*Equus excelsus*	
		Ashley River, redeposited	*Hipparion venustum*	
		Peace Creek, "	*H. princeps = Equus ? fraternus*	
PLIOCENE	Upper	18. Pliohippus Proversus Zone		
		Upper Etchegoin, Cal.	*Pliohippus proversus*	
	Middle	17. Glyptotherium-Pliohippus simplicidens Zone		
		Blanco, Tex.	*Pliohippus simplicidens*, etc.	
		16. Ilingoceras-Pliohippus Zone		
		Thousand Creek, Nev.		
		Rattlesnake, Oreg.	*Pliohippus spectans*	
	Early	15. Pliauchenia-Pliohippus Fairbanksi Zone		
		Lower Etchegoin, Cal.	*Pliohippus coalingensis*	
		Ricardo (upper), Cal.	*P. fairbanksi, Pliohippus tantalus*	
	Lower	14. Pliauchenia-Peraceras Zone		
	Late	Republican River, Kan.	*Pliohippus nobilis*, (?) *Merychippus republicanus, Protohippus*	
		Devil's Gulch (upper), Nebr.	*Hypohippus matthewi*	
		Alachua Clays, Fla.	*Hipparion ingenuum*	
		Ricardo (lower), Cal.	" *mohavense callodonte, Pliohippus tantalus*	
		Snake Creek (upper), Nebr.	*Pliohippus leidyanus*	
	Early	13. Procamelus-Hipparion Zone		
		Fort Niobrara, Nebr.	*Pliohippus mirabilis, P. pernix, P. supremus*	
		Little White River, So. Dak.	*Parahippus* *P. cognatus*	*Hipparion affine, Protohippus niobrarensis, H. whitneyi*, etc.
		Clarendon, Tex.	*Protohippus* *P. perditus, P. placidus*, etc.	
		Santa Fé Marls (upper) N. Mex.		
	Transition	12. Santa Fé Marls (lower), N. Mex.	*Merychippus calamarius*	
		Snake Creek (lower), Nebr.	*Merychippus calamarius, M. insignis*	
MIOCENE	Upper	11. Procamelus-Merychippus calamarius Zone		
		Barstow, Cal., Temblor	*Merychippus sumani, M. intermontanus*	
		San Pablo, Cal.		
		Temblor, Cal. (upper)	*Merychippus californicus*	
	Late Middle	10. Merychippus sejunctus Zone		
		Pawnee Creek, Col. Deep River, Mont.	*Merychippus paniensis, M. labrosus, M. sejunctus, M. sphenodus, M. campestris*	*Parahippus pawniensis, P. coloradensis, Hypohippus osborni*
	Early Middle	9. Ticholeptus-Merychippus Zone		
		Virgin Valley, Nev. Mascall, Ore. Sheep Creek, Nebr. Phillips Ranch, Cal.	Primitive species of *Merychippus, M. seversus, M. relictus, M. isonesus* *Parahippus avus, P. brevidens, P. gracilis*	*Archæohippus, Hypohippus equinus*, etc.
	Lower	8. Merycochœrus-Parahippus Zone		
		Upper Harrison, Nebr.	*Parahippus* very abundant *P. nebrascensis, P. tyleri, P. pawniensis, P. atavus*, etc.	
		Upper Rosebud, So. Dak.		
		7. Promerycochœrus-Miohippus Zone		
		Lower Harrison, Nebr.	*Miohippus gemmarosæ, ?Kalobatippus agatensis*	?Primitive species of *Parahippus* *?P. pristinus, P. tyleri*
		" Rosebud, So. Dak.		
		Upper John Day, Ore.	*Miohippus condoni, M. acutidens*	*Kalobatippus præstans*
OLIGOCENE	Upper	6. Diceratherium-Miohippus Zone		
		Middle John Day, Ore.	*Miohippus anceps, M. equiceps, M. brachylophus, M. longicristis, M. primus, M. quartus*	
		5. Leptauchenia-Miohippus Zone	*Miohippus meteulophus*	
		= Protoceras Zone	*Miohippus brachystylus, M. intermedius, M. crassicuspis, M. validus, M. gidleyi*	
	Middle	4. Upper Oreodon Zone		
		Brule, So. Dak.	*Mesohippus eulophus*	
		3. Middle Oreodon Zone	*Mesohippus obliquidens*	
		= Metamynodon Zone	*Mesohippus trigonostylus*	
		2. Lower Oreodon Zone		
		Brule, So. Dak.	*Mesohippus*, ? *M. bairdii*, ? *M. exoletus*, ? *M. cuneatus*	
	Lower	1. Titanotherium-Mesohippus Zone		
		Chadron, So. Dak.	*Mesohippus celer*	
		Pipestone Creek, Mont.	*Mesohippus westoni, M. latidens, M. montanensis*	
		Swift Current Creek, Assiniboia	Primitive species of *Mesohippus, M. præcocidens*, etc.	

SYSTEMATIC REVISION OF THE EQUIDÆ WITH TYPE FIGURES OF THE SPECIES.

Type Terms in Vertebrate Palæontology as Employed by the Author in this Memoir.

Type terms and usage in vertebrate palæontology acquire a somewhat different significance than in invertebrate palæontology (Schuchert) or in zoölogy (Allen).

In this memoir the *type specimen* first mentioned by the author is regarded as the *holotype* or *lectotype.*

Genotype.— The type specimen of the genus and species.

Type (including *Holotype* and *Lectotype*).— The actual individual specimens mentioned by the author in his type description, equivalent to holotype in the strict modern usage. *Holotype* is used where the species is founded on one specimen primarily, others, if any, being paratypes. A *lectotype* may be subsequently selected out of a series of cotypes or paratypes (*sensu strictu*), and in this Memoir is always the first mentioned specimen.

Cotype (including *paratype*).— The second and subsequent specimens belonging to other individuals mentioned by the author in his type description; in palæontology equivalent to *paratype* in the more strict modern usage of terms.

Paratype.— Specimen or specimens placed by the author with the type, of supposedly equal value and amplifying the characters of the species.

Neotype.— The specimen chosen in a subsequent paper by the original or another author as referable to the same species and amplifying the characters of the type by affording fuller material for description.

Topotype.— A specimen subsequently found and described from the same *locality* and geologic level as the type.

GENUS **MESOHIPPUS** Marsh, 1875.

Amer. Jour. Sci. and Arts (3) Vol. IX, Mar. 1875, p. 248.

Genotype.— *Anchitherium* (*Palæotherium*) *bairdii* Leidy, from the Lower Oligocene, lower Oreodon beds of the White River series of South Dakota.

Nineteen species have been described under this stage of equine evolution between the years 1850 and 1908, besides six which have been removed to *Miohippus.*

The principal stages of *character genesis* and of *proportional evolution* comprised within the genus *Mesohippus* are as follows:

1. Premolars $\frac{2-4}{2-4}$ of equal or less length than molars $\frac{1-3}{1-3}$.
2. Premolars $\frac{2-4}{2-4}$ typically of equal or less width than molars $\frac{1-3}{1-3}$.
3. Facial (preorbital) less than cranial (orbito-postorbital) length.
4. Molars typically with internal cingulum vestigial or wanting except in lower Titanotherium zone, external cingulum more or less clearly defined.
5. Lophs more or less interrupted, *i. e.* bunolophodont, or crested, *i. e.* lophodont.
6. Hypostyle absent, rudimentary, or strongly developed (*M. trigonostylus*).
7. A rudimentary crochet in *M. trigonostylus.*
8. A shallow lachrymal fossa or a lachrymo-malar fossa (Plate 1).

Comparison of the type and referred skulls (Plate 1) and dental series (Plate 2) proves conclusively that *Mesohippus* embraces not only many stages of evolution during the period of the Titanotherium zone and of the Oreodon zone but also a number of distinct and separate phyla, as follows:

I. Titanotherium zone species.

Teeth moderately crested
No hypostyle
Lateral digits less reduced, Mtc. V splint apparently long
Mts. cuboid facet absent or very small
M^3 somewhat reduced

II. Oreodon zone species, *Mesohippus bairdii* group.

Teeth moderately crested
Hypostyle distinct
Upper premolars equalling or slightly smaller than molars
Facial region short
Shaft of digits slightly less elongate
Mts. III cuboid barely in contact

III. Metamynodon zone, *M. trigonostylus* group.

Hypostyle very prominent, triangular
Lophs of bunolophodont type

IV. Titanotherium and Oreodon zone, *Mesohippus eulophus* group.

Hypostyle persistently rudimentary
Lophs typically crested
Lachrymal fossæ deep, superior in position

TITANOTHERIUM-MESOHIPPUS ZONE. 1. LOWER OLIGOCENE.

This life zone, geographically distributed in South Dakota, Colorado, Nebraska, Montana, and British Columbia, as described above, contains the smallest and most primitive species of *Mesohippus.*

Mesohippus celer Marsh, 1874.

Plate 2.9. Text Fig. 17.

Anchitherium celer, Marsh, O. C. "Notice of New Equine Mammals from the Tertiary Formation," *Amer. Jour. Sci. and Arts* (3) Vol. VII, No. 39, Mar. 1874, p. 251, no figure.

Horizon and locality.— Miocene of Nebraska (Marsh). Level unrecorded, probably Lower Oligocene, Titanotherium zone. Type collected by W. A. Jones.

Type.— Yale Mus. 11302, superior molars, p^4–m^3, in a portion of the right maxillary. Measurements: m$^{1-3}$ .027 (Marsh), .0295 (Gidley); m^1 a.p. .010, tr. .015; m^3 a.p. .0085, tr. .012.

Type figure.— Plate 2.9, text Fig. 17 of this Memoir.

I. Type Descriptions of the Species of Mesohippus in Chronologic Order.

Date	Original name and author	Present reference	Locality	Life zone
1850	*Palæotherium bairdii* Leidy	*Mesohippus bairdii*	Big Badlands, So. Dak.	?Lower Oreodon zone
1873.1	*Anchitherium cuneatum* Cope	" *cuneatus*	Cedar Creek, Logan Co., Col.	?Oreodon zone
1873.2	" *exoletum* Cope	" *exoletus*	" " " "	?Oreodon "
1874	" *celer* Marsh	" *celer*	Nebraska ("Miocene of Nebraska")	Titanotherium zone
1889	" *westoni* Cope	" *westoni*	Cypress Hills, Assiniboia, Can.	" " (?Lower)
1895	*Mesohippus copei* Osborn and Wortman	= *Colodon copei*		
1904.1	" *latidens* Douglass	*Mesohippus latidens*	Thompson's Creek, southw. Montana	?Titanotherium zone
1904.2	" *montanensis* Osborn	" *montanensis*	Pipestone Creek, Mont.	Lower Titanotherium zone
1904.3	" *hypostylus* Osborn	" *hypostylus*	Big Badlands, So. Dak.	Upper Titanotherium zone
1904.4	" *proteulophus* Osborn	" *proteulophus*	" " " "	" " "
1904.5	" *obliquidens* Osborn	" *obliquidens*	" " " "	Lower Middle Oreodon zone
1904.6	" *eulophus* Osborn	" *eulophus*	Cedar Creek, Col.	Upper Oreodon zone, horizon B
1905.1	" *præcocidens* Lambe	" *præcocidens*	Cypress Hills, Assiniboia, Can.	?Titanotherium-?Leptauchenia zone
1905.2	" *propinquus* Lambe	" *propinquus*	" " " "	" " "
1905.3	" *stenolophus* Lambe	" *stenolophus*	" " " "	" " "
1905.4	" *planidens* Lambe	" *planidens*	" " " "	" " "
1905.5	" *assiniboiensis* Lambe	" *assiniboiensis*	" " " "	" " "
1908	" *portentus* Douglass	" (?)*portentus*	Pipestone Creek, Mont.	? " "
1918	" *trigonostylus* Osborn	" *trigonostylus*	Big Badlands, So. Dak.	Metamynodon zone

II. Types as Recorded or Inferred in 1917 in Geologic Succession.

Date	Species, Present reference	Life zone	Formation, Beds	Locality	Age
1904.6	*Mesohippus eulophus* Osborn	Upper Oreodon zone, horizon B	Cedar Creek, Col.	Cedar Creek, Logan Co., Col.	?Upper Middle Oligocene
1904.5	" *obliquidens* Osborn	Lower middle Oreodon zone	Brule formation	Big Badlands, So. Dak.	?Lower Middle Oligocene
1918	" *trigonostylus* Osborn	Metamynodon "	" "	" " " "	" " "
1873.1	" *cuneatus* Cope	?Oreodon "	Cedar Creek, Col.	Cedar Creek, Logan Co., Col.	?Middle Oligocene
1873.2	" *exoletus* Cope	?Oreodon "	" " "	" " " " "	? " "
1850	" *bairdii* Leidy	?Lower Oreodon "	Brule formation	Big Badlands, So. Dak.	Middle Oligocene
1905.5	" *assiniboiensis* Lambe	?Titanotherium-?Leptauchenia zone	Above Cypress Hills, Assiniboia	Cypress Hills, Assiniboia	Oligocene
1905.4	" *planidens* Lambe	" " "	" " " "	" " "	"
1905.3	" *stenolophus* Lambe	" " "	" " " "	" " "	"
1905.2	" *propinquus* Lambe	" " "	" " " "	" " "	"
1905.1	" *præcocidens* Lambe	" " "	" " " "	" " "	"
1904.4	" *proteulophus* Osborn	Upper Titanotherium zone	Chadron formation	Big Badlands, So. Dak.	Lower Oligocene
1904.3	" *hypostylus* Osborn	" " "	" "	" " " "	" "
1908	" (?) *portentus* Douglass	?Titanotherium zone	Pipestone Creek, Mont.	Pipestone Creek, Mont.	" "
1904.2	" *montanensis* Osborn	Lower Titanotherium zone	" " "	" " "	" "
1904.1	" *latidens* Douglass	?Titanotherium zone	Thompson's Creek, southw. Mont.	Thompson's Creek, southw. Mont.	" "
1889	" *westoni* Cope	Titanotherium (?Lower) zone	Cypress Hills, Assiniboia	Cypress Hills, Assiniboia	" "
1874	" *celer* Marsh	" " "	?Chadron	Nebr. ("Miocene of Nebraska")	? " "

Characters.—(Osborn, 1904) Molar series somewhat smaller than those of *M. bairdii;* protoloph and metaloph of nearly equal length; molar crowns short, brachyodont, less elevated than in *M. latidens* or in *M. bairdii;* no hypostyle; m^3 of very small size.

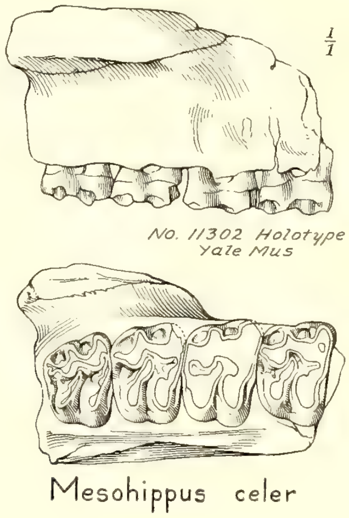


Fig. 17. *Mesohippus celer* Marsh, Yale Mus. 11302, holotype, p^4–m^3. Lateral and crown views. Natural size.

Mesohippus westoni Cope, 1889.

Plate 2.10. Text Fig. 18.

Anchitherium westoni sp. nov.,[1] Cope, E. D. "The Vertebrata of the Swift Current River, II," *Amer. Naturalist,* Vol. XXIII, No. 267, Mar. 1889, p. 153, no figure. "On Vertebrata from the Tertiary and Cretaceous Rocks of the North West Territory. I.—The Species from the Oligocene or Lower Miocene beds of the Cypress Hills," *Geol. Surv. of Canada, Contr. to Canadian Palæontology,* Vol. III (quarto), Pt. I, 1891, p. 20, Pl. xiv, figs. 1, 2, 2a.

Horizon and locality.—Eastern end of the Cypress Hills, Assiniboia, Canada, at the headwaters of Swift Current Creek, Titanotherium zone. Type collected by T. C. Weston in 1884.

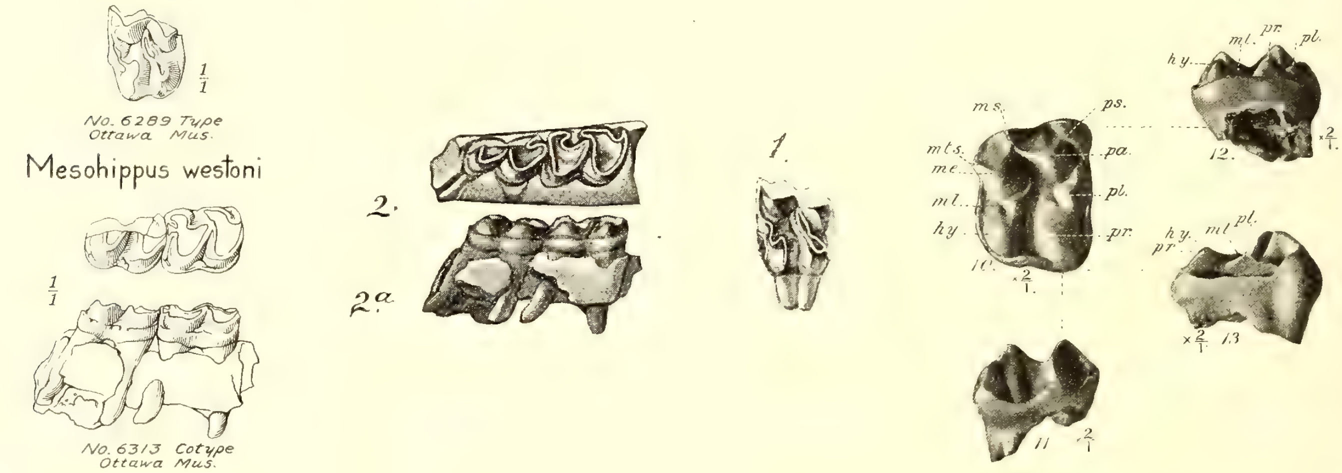


Fig. 18. (Middle) Original figures of type and cotype of *Mesohippus westoni* Cope; type (1), Ottawa Mus. 6289, a fractured upper molar, cotype (2, 2*a*), two doubtfully associated right lower molars, Ottawa Mus. 6313. After Cope, 1891, Pl. xiv, figs. 1, 2, 2*a*. (Left) Same teeth redrawn under direction of Osborn. All these figures natural size. (Right) Original figure of additional upper molar (topotype) from the type locality, Ottawa Mus. 6293, collected by Lawrence M. Lambe. After Lambe, 1905, Pl. xiv, figs. 1–4. Three-halves natural size.

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[1] Cope, E. D. "The White River Beds of Swift Current River, Northwest Territory," *Amer. Naturalist,* Vol. XIX, Feb. 1885, p. 163, listed *Anchitherium* sp. indet. No figure.

Type.— Ottawa Mus. 6289, a fractured right upper molar and two doubtfully associated right lower molars (Ottawa Mus. 6313). Measurements: m^2 a.p. .0095, tr. .012+, height of hypocone .004, ectoloph .005; associated lower molar (paratype) a.p. .0095. The type upper molar described by Cope is imperfect, the outer slope of the ectoloph is missing, and the anterior border of the crown, including the greater part of the protoloph, is very much damaged. *Topotype.*[1] Ottawa Mus. 6293 (1905). Second superior molar of right side (Lambe, *op. cit.* Plate XIV, Figs. 1–4). Measurements: tr. .013, a.p. .0102, height of ectoloph .0062. (Lambe, 1915, p. 244) The topotype described by Lambe is a perfect tooth, in which the absence of the hypostyle indicates that this species is one of the most primitive of the known horses of Oligocene age.

Type figure.— Text Fig. 18 of this Memoir.

Characters.— (Osborn, 1904) Superior molar extremely primitive and brachyodont; transverse diameter proportionately great; crests low and obtuse; persistent, well defined internal cingulum; protoloph with defined protoconule; metaloph continuous, with metaconule somewhat less clearly defined; no hypostyle.

Mesohippus latidens Douglass, 1903.

Text Fig. 19.

Mesohippus latidens sp. nov., Douglass, Earl. "New Vertebrates from the Montana Tertiary," *Ann. Carnegie Mus.*, Vol. II, No. 2,1903, pp. 161–162, fig. 7.

Horizon and locality.—Lower White River beds, Thompson's Creek, near Three Forks, southwestern Montana. Type collected by Earl Douglass in 1899.

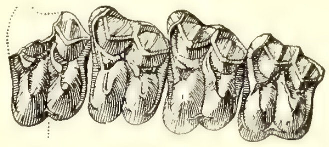

Fig. 19. Original figure of type of *Mesohippus latidens* Douglass, Carnegie Mus. 751, fourth upper premolar and three molars, p^4–m^3, of the left side. Natural size. After Douglass, 1904, fig. 7, p. 161.

Type.— Carnegie Mus. 751, four superior grinders, p^4–m^3, of the left side. Measurements: m^{1-3} .032; m^1 a.p. .010, tr. .016.

Type figure.— Text Fig. 19 of this Memoir.

Characters.— (Douglass, 1903, p. 161) "The most striking distinguishing character of the teeth is the extreme transverse as compared with the antero-posterior diameter and much greater width of the anterior than of the posterior portions." (Osborn, 1904) Much more progressive than *M. westoni;* protoloph and metaloph more elevated; internal cingulum not continuous; hypostyle wanting; distinguished from *M. westoni* and *M. celer* by prominent parastyle and elongate protoloph so that anterior half of the crown is much broader than the posterior half.

Mesohippus montanensis Osborn, 1904.

Plate 2.1. Text Fig. 20.

Mesohippus montanensis, sp. nov., Osborn, Henry F. "New Oligocene Horses," *Bull. Amer. Mus. Nat. Hist.*, Vol. XX, Art. XIII, May 28, 1904, p. 170, no figure.

Horizon and locality.— Type and cotypes from Pipestone Creek beds, Jefferson County, Montana. Lower Titanotherium zone. Type collected by W. D. Matthew of Am. Mus. Expedition of 1902.

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[1] Lambe, Lawrence M. "On the Tooth-Structure of *Mesohippus westoni* (Cope)," *Amer. Geologist*, Vol. XXXV, Apr., 1905, pp. 243–245, pl. XIV, figs. 1–4.

Type.— Amer. Mus. Nat. Hist. 9662, dp$^{2-4}$, m^1. Measurements: m^1 a.p. .0105, tr. .014. *Cotypes.* Dp$^{2-4}$ (Amer. Mus. Nat. Hist. 9661), p^2–m^1 (Amer. Mus. Nat. Hist. 9663).

Type figure.— Plate 2.1, text Fig. 20 of this Memoir.

Characters.— (Osborn, 1904, p. 170) "Distinguished from *M. celer* by full size of m^3; from *M. westoni* by sharp elevation of crests and absence of internal cingulum; from *M. latidens* by smaller parastyle and sub-equal length of protoloph and metaloph. Molars more quadrate in form than in *M. latidens*. Protoconule quite distinct in protoloph; metaconule well defined on base of metaloph. Hypostyle absent or extremely rudimentary. A fore foot associated with a single m^3 of the same species exhibits a large splint of Mtc. v."

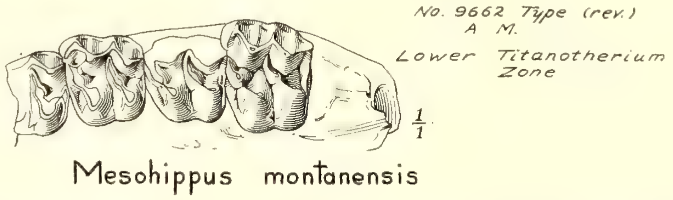

Fig. 20. Type of *Mesohippus montanensis* Osborn, Amer. Mus. 9662, dp$^{2-4}$, m^1. Natural size. Reversed in drawing.

Mesohippus portentus Douglass, 1908.

Text Fig. 21.

Mesohippus portentus sp. nov., Douglass, Earl. "XV. Fossil Horses from North Dakota and Montana," *Ann. Carnegie Mus.*, Vol. IV, Nos. III, IV, Apr. 1, 1908, pp. 268–269, Pl. lxv, type, figs. 2, 3, paratypes, figs. 1, 4.

Horizon and Locality.— Type and paratypes from "Lower White River ('Titanotherium') beds, Pipestone Creek, near Whitehall, Montana." Type collected by Earl Douglass.

Type.— Carnegie Mus. 1622, a second right upper molar. Measurements: "Antero-posterior diameter of crown 13.3 mm., transverse diameter 18 mm., length of protoloph 12.2 mm., length of metaloph 12 mm., height of hypocone 8.1 mm." *Paratypes.* A left upper premolar (Carn. Mus. 1624), a left m^3 (Carn. Mus. 1623), two lower molars (Carn. Mus. 1633), a lower molar (Carn. Mus. 1634).

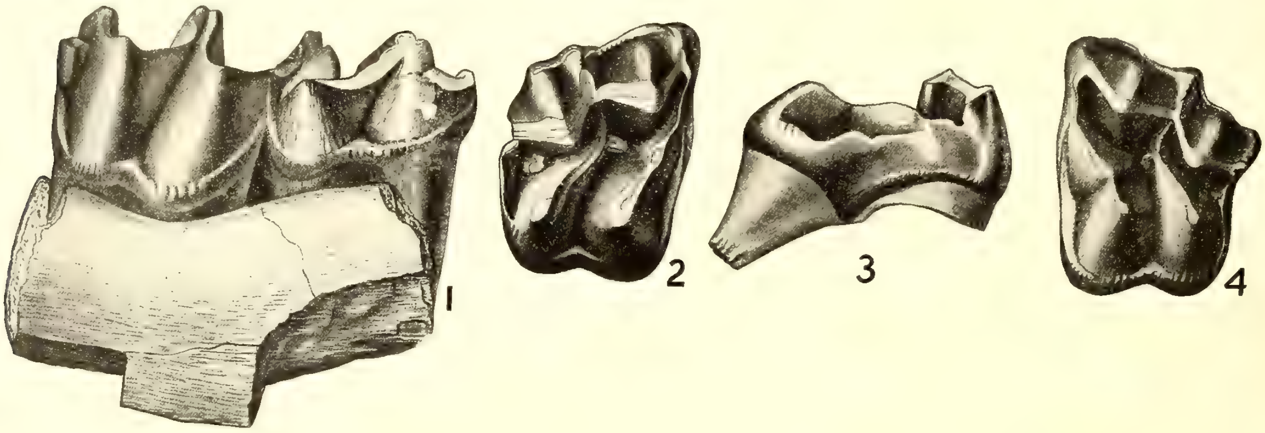

Fig. 21. Original figures of type and paratypes of *Mesohippus portentus* Douglass. Type (2, 3), Carnegie Mus. 1622, m^2 of the right side; paratypes (1), Carnegie Mus. 1633, two lower molars, and (4) Carnegie Mus. 1623, a left m^3. Greatly enlarged. After Douglass, 1908, Pl. lxv, figs. 1–4.

Type figure.— Text Fig. 21 of this Memoir.

Characters.— (Douglass, 1908) "(1) Size large and (2) crests of molars high for a horse from this horizon, (3) ectoloph very oblique, (4) protoloph and metaloph nearly equal in length, (5) protoloph large and connected with the parastyle, (6) metaloph narrow and nearly connected with ectoloph, (7) protoconule easily distinguishable, but (8) metaconule absent, (9) a crotchet present on the metaloph, and (10) a small conule in the posterior valley of the tooth, (11) a rudiment of a cingulum between protocone and hypocone, (12) parastyle and (13) hypostyle small."

(Osborn, 1918) The exceptionally progressive characters of these type molar teeth, including the purely lophoid metaloph and the rudimentary crochet, indicate that this animal may belong to a higher geologic horizon than the Titanotherium zone.

Mesohippus hypostylus Osborn, 1904.

Plates 1.2, 2.3. Text Fig. 22.

Mesohippus hypostylus, sp. nov., Osborn, Henry F. "New Oligocene Horses." *Bull. Amer. Mus. Nat. Hist.* Vol. XX, Art. XIII, May 28, 1904, pp. 170, 171, fig. 2, pl. V A.

Horizon and Locality.— Cheyenne River, South Dakota, Upper Titanotherium zone. Type collected by the Am. Mus. Expedition of 1894.

Type.— Amer. Mus. 1180, preorbital portion of skull, palate with complete series of grinding teeth on both sides, p^1–m^3. Measurements: p^1–m^3 .075; m$^{1-3}$ .032; m^1 a.p. .010, tr. .0135; vertical hypocone .006; ectoloph .0075.

Type figure.— Text Fig. 22 of this Memoir.

Characters.— (Osborn, 1904, p. 170) "Distinguished from the preceding species by (1) a clearly defined but rudimentary hypostyle just budding off from the posterior cingulum, (2) by protoloph tending to unite with paracone [parastyle]; from *M. bairdi*[*i*] by more rudimentary hypostyle and less elevated crests. Metaloph sharp; metaconule not defined at base. Pm^1 small. Skull with preorbital [lachrymal] fossa apparently deeper than in *M. bairdi*[*i*]."

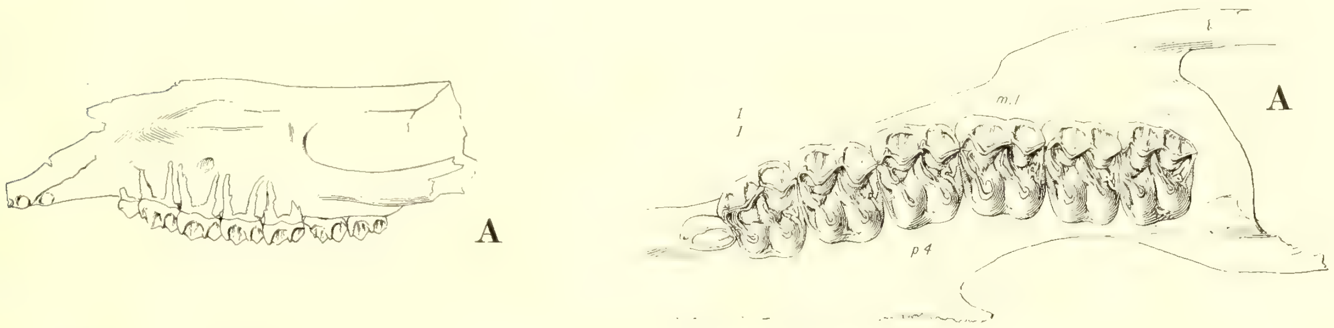

Fig. 22. Original figures of the type of *Mesohippus hypostylus* Osborn, Amer. Mus. 1180, which consists of preorbital portion of skull and palate with complete series of grinding teeth on both sides, p^1–m^3. Skull one half natural size, teeth natural size.

Mesohippus proteulophus Osborn, 1904.

Plates 1.1, 2.2. Text Fig. 23.

Mesohippus proteulophus, sp. nov., Osborn, Henry F. "New Oligocene Horses," *Bull. Amer. Mus. Nat. Hist.*, Vol. XX, Art. XIII, May 28, 1904, pp. 171–172, no figure.

Horizon and locality.— Badlands near Cheyenne River, South Dakota, Upper Titanotherium zone. Type collected by Am. Mus. Expedition of 1892.

Type.— Amer. Mus. 514a, upper grinding teeth, p^4–m^2. *Cotype.* Amer. Mus. 1208, a lower jaw.

Type figure.— Plates 1.1, 2.2, text Fig. 23 of this Memoir.

Characters.— (Osborn, 1904) "This is a relatively large animal for the Titanotherium beds, and is the oldest horse known with perfect crests on the molar teeth — hence the name *proteulophus.* The superior molars are readily distinguished by: (1) their large size; p^3–m^2 measure .037 mm. as compared with .0335 for the same teeth in *M. bairdi*[*i*]; (2) by the primitive absence of a distinct hypostyle; (3) especially by the very advanced or progressive condition of the proto-

and metalophs which are continued to the ectoloph, and are very little divided, thus resembling those of *M. eulophus;* (4) the external cingulum sweeps upward across the parastyle instead of rising with it. The cotype lower teeth p_2 to m_3 measure 79 mm., indicating an animal of large size."

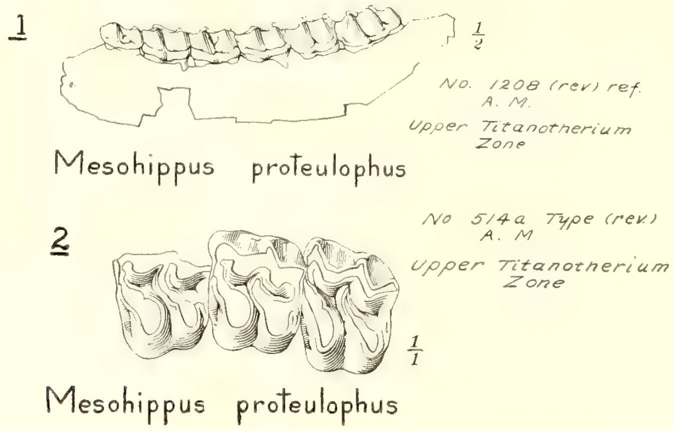

Fig. 23. (2) Type of *Mesohippus proteulophus* Osborn, Amer. Mus. 514a, p^4–m^2. Natural size. (1) Amer. Mus. 1208, a referred specimen. One-half natural size. Both figures reversed in drawing.

Mesohippus præcocidens Lambe, 1905.

Text Fig. 24(14).

Mesohippus præcocidens, sp. nov., Lambe, Lawrence M. "Fossil Horses of the Oligocene of the Cypress Hills, Assiniboia," *Trans. Roy. Soc. Canada,* 2nd Ser., Vol. XI, Sec. IV, 1905–1906, issued Aug. 1905, p. 46, Pl. ii, fig. 2.

Horizon and locality.— Oligocene deposits capping the Cypress Hills, Assiniboia, Titanotherium zone to Leptauchenia zone. This type is regarded (Lambe) as of Titanotherium zone age. Type collected by Lambe.

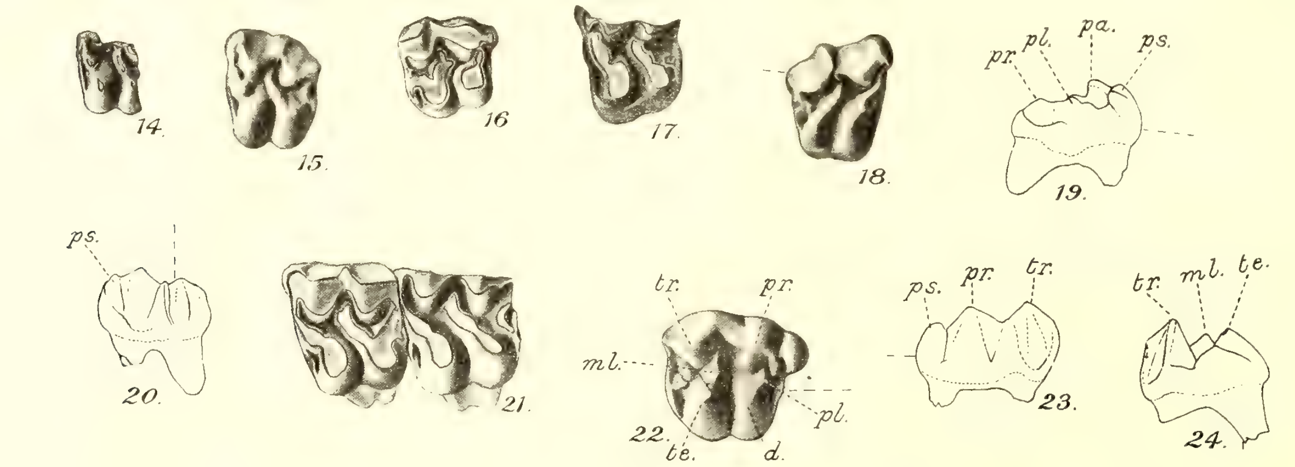

Fig. 24. Original figures of Lambe's types of *Mesohippus* from the Cypress Hills, Assiniboia, Canada. Reproduced direct from Lambe's original drawings of his type figures. All figures natural size. After Lambe, 1905–1906, Pl. ii, figs. 2–6, 6a, 6b, 7, 8, 8a, 8b.

(14) Crown view of type of *Mesohippus præcocidens* Lambe, Ottawa Mus. 6297, left upper molar. Lambe, Pl. ii, fig. 2.

(15) Crown view of cotype of *M. propinquus* Lambe, Ottawa Mus. 6290, m^2 of the left side. Lambe, pl. ii, fig. 3.

(16) Crown view of upper premolar referred to *M. propinquus* Lambe, Ottawa Mus. Lambe, Pl. ii, fig. 4.

(17) Crown view of upper premolar, Ottawa Mus., referred to *M. brachystylus* Osborn. Lambe, Pl. ii, fig. 5.

(18, 19, 20) Type of *Mesohippus stenolophus* Lambe, Ottawa Mus. 6302, an upper molar. (18) Crown view, (19) anterior aspect, (20) exterior view. Lambe, Pl. ii, figs. 6, 6a, 6b.

(21) Crown view of type of *Mesohippus planidens* Lambe, Ottawa Mus. 6304, m^{1-2}. Lambe, Pl. ii, fig. 7.

(22, 23, 24) Crown view of type of *Mesohippus assiniboiensis* Lambe, Ottawa Mus. 6305, p^2. (23) External aspect of same, (24) posterior aspect of same. Lambe, Pl. ii, figs. 8, 8a, 8b.

Type.— Ottawa Mus. 6297, an imperfect left upper molar. Measurements: height of protocone, .0047.

Type figure.— Text Fig. 24 of this Memoir.

Characters.— (Lambe, 1905) "This tooth is about the size of, or possibly smaller than, *M. westoni*, but is more progressive in every way. There is an entire absence of an internal cingulum, the cross crests are better developed and relatively higher with steeper slopes. The protoconule is relatively larger, and the metaconule, although defined, scarcely breaks the continuity of the metaloph which unites in a decided manner with the ectoloph. The protoconule is distinctly defined in the protoloph and connects closely with the forward slope of the paracone. The hypocone has about the same height as the protocone. The anterior cingulum is strong."

Lambe observes (*op. cit.* p. 51) that *M. præcocidens* is nearly related to and more advanced than *M. westoni* Cope or *M. montanensis* Osborn of the Titanotherium zone.

Mesohippus propinquus Lambe, 1905.

Text Fig. 24(15,16).

Mesohippus propinquus, sp. nov., Lambe, Lawrence M. "Fossil Horses of the Oligocene of the Cypress Hills, Assiniboia," *Trans. Roy. Soc. Canada*, 2nd Ser., Vol. XI, Sec. IV, 1905–1906, issued Aug., 1905, p. 47, Pl. ii, figs. 3, 4.

Horizon and locality.— Oligocene deposits capping the Cypress Hills, Assiniboia, Titanotherium zone to Leptauchenia zone. This type is regarded (Lambe) as of Oreodon zone age. Type collected by Lambe.

Type.— Ottawa Mus. 6298, second right upper premolar, worn, p^2 (Pl. ii, fig. 4). Measurements: p^2 a.p. .013, tr. .0135. *Cotypes.* Second left upper molar, Ottawa Mus. 6290 (Pl. ii, fig. 3); second right upper molar, unworn, Ottawa Mus. 6291.

Type figure.— Text Fig. 24 of this Memoir.

Characters.— (Lambe, 1904, pp. 47–48) *Type.* Closely allied to and resembling *M. bairdii* although distinct, slightly larger and more primitive than *M. bairdii*, proportions different. *Cotype.* "In the unworn tooth, Fig. 3 (left upper m^2), the ectoloph is well elevated above the cross crests in which the protocone and hypocone are conspicuously higher than the conules. The hypocone exceeds the protocone in height. The protoconule is well defined and distinctly breaks the continuity of the protoloph. The metaloph is fairly continuous and shows a disposition to unite with the ectoloph which, however, it does not reach. The hypostyle is connected at its inner end with the posterior cingulum and outwardly abuts against the ectoloph; it is of fair size. In the ectoloph the mesostyle is conspicuous, the parastyle is flattened and connects with the protoloph, and the ribs are faintly shown. There is no trace of an internal cingulum."

Lambe regards *M. propinquus* as nearly related to and more primitive than *M. bairdii* of the Oreodon zone.

Mesohippus stenolophus Lambe, 1905.

Text Fig. 24(18,19,20).

Mesohippus stenolophus, sp. nov., Lambe, Lawrence M. "Fossil Horses of the Oligocene of the Cypress Hills, Assiniboia," *Trans Roy. Soc. Canada*, 2nd Ser., Vol. XI, Sec. IV, 1905–1906, issued Aug., 1905, p. 48, Pl. ii, figs. 6, 6a, 6b.

Horizon and locality.— Oligocene deposits capping the Cypress Hills, Assiniboia, Titanotherium zone to Leptauchenia zone. This type is regarded as of Leptauchenia zone age. Type collected by Lawrence M. Lambe.

Type.— Ottawa Mus. 6302, first left upper molar, unworn. Measurements: m^1 a.p. .014. *Cotype.* M^3, right, Ottawa Mus. 6302. Measurements: a.p. .0125, tr. .015.

Type figure.— Text Fig. 24 of this Memoir.

Characters.— (Lambe, 1905, pp. 48–49) "These teeth represent an apparently undescribed species of *Mesohippus* larger than *M. brachystylus*, but resembling it in some particulars. The differences noticed are: (1) the greater relative size of m^3 with a more pronounced obliquity of the cross crests in these teeth; (2) the greater length of the metaloph, which in m^3 is connected with the ectoloph, and (3) the intimate connection of the hypostyle with both the posterior cingulum and the metastyle. The resemblances are: — (1) somewhat similar general proportions with about the same degree of development of the protoconule and a like suppression of the metaconule; (2) the parastyle and internal cingulum similarly developed. A special character of *M. stenolophus*, seen in *m*^{3}, is the oblique crossing of the parastyle by the external cingulum which rises rapidly from without and appears very distinctly on the upper anterior surface of the style (Figs. 6a, 6b). The cross crests are narrow in proportion to their height, a feature suggested in the name given to the species."

Lambe regards *M. stenolophus* (*op. cit.*, p. 51) as approaching closely *Miohippus brachystylus* Osborn of the Leptauchenia zone.

Mesohippus planidens Lambe, 1905.

Text Fig. 24(21).

Mesohippus planidens, sp. nov., Lambe, Lawrence M. "Fossil Horses of the Oligocene of the Cypress Hills, Assiniboia," *Trans. Roy. Soc. Canada*, 2nd Ser., Vol. XI, Sec. IV, 1905–1906, issued Aug., 1905, p. 49, Pl. ii, fig. 7.

Horizon and locality.— Oligocene deposits capping the Cypress Hills, Assiniboia, Titanotherium zone to Leptauchenia zone. This type is regarded as of Protoceras zone age. Type collected by Lawrence M. Lambe.

Type.— Ottawa Mus. 6304, first and second left upper molars, worn. Measurements: m$^{1-2}$ .031; m^1 a.p. .015, tr. .0178.

Type figure.— Text Fig. 24 of this Memoir.

Characters.— (Lambe, 1905, p. 49) "These teeth indicate a species of about the size of *M. intermedius*, Osborn and Wortman, from the Upper Oligocene, Protoceras beds of South Dakota, but smaller than *M. validus*, Osborn, from the same horizon and state. They differ from those of *M. intermedius* in the greater obliquity of the protoloph and metaloph in which respect they resemble those of *M. obliquidens*, Osborn. The teeth are brachyodont, and are devoid of an internal cingulum. Externally the ectoloph is noticeably flat with only a slight development of the parastyle and mesostyle, the ribs are absent or but feebly indicated, and the metastyle is particularly inconspicuous. The hypostyle is of fair size, curved and attached at either end to the posterior cingulum. The cross crests are oblique to the ectoloph, well elevated, and moderately continuous, the metaloph more so than the protoloph. The protoconule slightly interrupts the protoloph and unites with the parastyle. The metaconule scarcely breaks the continuity of the metaloph which is sharply separated from the ectoloph and develops a rudimentary crochet. The protocone and hypocone are not so elevated as the ectoloph. The specific name has reference to the flattened condition of the ectoloph."

Lambe observes (*op. cit.* p. 51) that *M. planidens* approaches in size *Miohippus intermedius* Osborn and Wortman from the Protoceras zone.

Mesohippus assiniboiensis Lambe, 1905.

Text Fig. 24(22,23,24).

Mesohippus assiniboiensis, sp. nov., Lambe, Lawrence M. "Fossil Horses of the Oligocene of the Cypress Hills, Assiniboia," *Trans. Roy. Soc. Canada*, 2nd Ser., Vol. XI, Sec. IV, 1905–1906, issued Aug., 1905, p. 50, Pl. ii, figs. 8, 8a, 8b.

Horizon and Locality.— Oligocene deposits capping the Cypress Hills, Assiniboia, Titanotherium zone to Leptauchenia zone. This type is recorded as of Protoceras zone age. Type collected by Lawrence M. Lambe.

Type.— Ottawa Mus. 6305, second right upper premolar, p^2, unworn. Measurements: p^2 a.p. .015, tr. .017; height or tritocone .0105; height of tetartocone .008.

Type figure.— Text Fig. 24 of this Memoir.

Characters.— (Lambe, 1905). (1) The type of larger size than that of *Miohippus intermedius* or *M. validus* from the Protoceras zone. (2) Greater development of parastyle than in *M. brachystylus*; (3) proto- and metalophs short, set at right angles to ectoloph; (4) deutero- and tetartocones of premolars strongly and equally developed; (5) protoconule much smaller than metaconule; (6) ectoloph with distinct mesostyle; (7) hypostyle tends to separate from posterior cingulum; (8) cingulum robust, high and sharp. Lambe observes (*op. cit.* p. 50) that this animal, known only from the second upper premolar, approaches most nearly in tooth development the much smaller *Miohippus brachystylus* Osborn. It most closely resembles *Miohippus validus* in size, but is considered even larger.

OREODON-MESOHIPPUS ZONE. 2. MIDDLE OLIGOCENE.

As described above, this zone is divided into three levels, viz., Lower Oreodon Zone, Middle Oreodon Zone (= Metamynodon Zone), Upper Oreodon Zone, each of which contains distinct specific stages or mutations. All the species of horses known in these overlying horizons exhibit a hypostyle on the superior molars. The horses are between eighteen and twenty inches in height at the withers.

Species Attributed to Lower Oreodon Zone 2.

Mesohippus bairdii Leidy, 1851.

Plates 1.3,4, 2.4,13, 39.15,18, 51.7,11. Text Figs. 25, 26.

Palæotherium bairdii, Leidy, Joseph. [Communication without title] *Proc. Acad. Nat. Sci. Phila.*, Vol. V, No. VI, (1850), Jan. 1851, p. 122. (Read Dec. 17, 1850.) No figure.

Anchitherium bairdii Leidy, full description and first figure, Leidy, Joseph. "Ancient Fauna of Nebraska: or a Description of Remains of Extinct Mammalia and Chelonia, from the Mauvaises Terres of Nebraska," *Smiths. Contr. to Knowl.*, Vol. VI, 1853, Pl. x, figs. 20, 21, Pl. xi, figs. 1, 8.

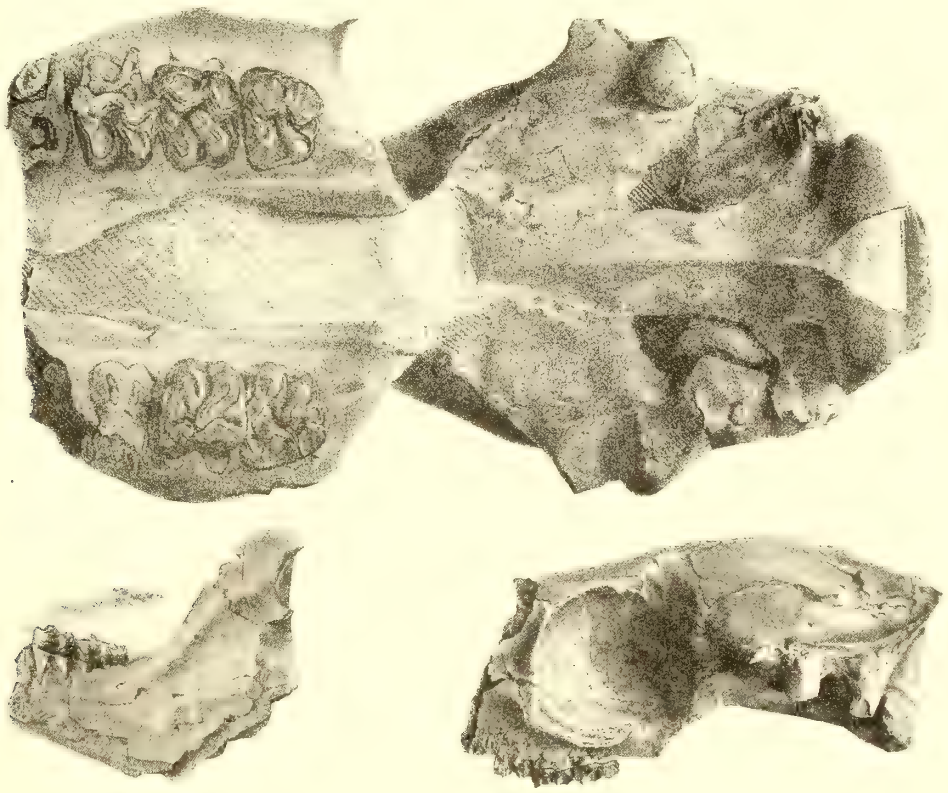

Fig. 25. Original figures of type and paratype of *Mesohippus bairdii* Leidy. (Upper and lower right figures) Palatal and side views of type skull, after Leidy, 1853, respectively Pl. x, fig. 21, Pl. xi, fig. 1; palatal view natural size, side view one-half natural size. (Left lower) Side view of paratype lower jaw, one-half natural size, reversed in reproduction from Leidy figure. After Leidy, 1853, Pl. xi, fig. 5.

Horizon and Locality.— Probably from the head of Bear Creek, Pennington County, South Dakota, the locality visited by ~~Thaddeus~~ alexander ([illegible]) Culbertson, the collector of this type.

Type and cotype.— (Leidy) "Palæotherium.— .... A second species was founded upon the cranium and a portion of the face containing the true molars; and the six superior and inferior molars of both sides of another individual." (*Proc.*

Acad. Nat. Sci. Phila. Vol. V, (1850), 1851, p. 122.) This skull ("Ancient Fauna of Nebraska," Pl. x, figs. 20, 21, Pl. xi, figs. 1, 2), superior molar teeth (Pl. xi, figs. 3, 4), and inferior teeth (Pl. x, figs. 12, 16, Pl. xi, figs. 5–8) were again referred to by Leidy as his *type* and *cotypes* (1853), as follows: "The specimens which we have an opportunity to study are as follows: — 1. Cranium proper, with a portion of the face containing on one side the last tooth and the other the last three molars. . . . The specimen was accompanied by several fragments of a lower jaw of which two contain the last two molars and one has the coronoid process nearly entire." ("Ancient Fauna of Nebraska," 1853, p. 68). Unfortunately these types and paratypes have not all been preserved. Part of the material described in Leidy's memoir of 1853, fragments of lower jaws (figs. 5–8, Pl. xi) are in the U. S. National Museum collection. (Gidley, letter Nov. 21, 1917) "The complete list of the [U. S. National Museum] pieces, now located in our collection, described or figured by Leidy as representing *M. bairdii* (Leidy) is as follows: 1. Posterior portions of both lower jaws. 'Ancient Fauna of Nebraska,' 1853, Pl. xi, fig. 5. (Mentioned on p. 68, of this work, as having accompanied the skull portion (not yet located) first described. I presume the skull and the jaw portions are parts of the same individual.) [? The type.] Cat. No. 8632. 2. Upper and lower jaws of both sides. Pl. x, fig. 14; Pl. xi, figs. 3, 4, 6, 7, and 8, Cat. No. 2359. 3. Portion of left lower jaw. Pl. x, fig. 15, Cat. No. 8633. 4. Unworn rt. lower molar, Pl. x, figs. 16 and 17, Cat. No. 8634. 5. Skull and lower jaws. 'Extinct Mammalian Fauna of Dakota and Nebraska,' 1869, p. 303, Cat. No. 3812."

Measurements: Type (Leidy, 1851, p. 122).

"Length of range of seven superior molars, ...	28–10	inches"
" " " " " inferior "	3	"
"Breadth of face on line with posterior superior molars	2–$\frac{1}{4}$	"

Type measurements estimated from Leidy's figures (Osborn, 1917): m^{1-3} .032; m^1 a.p. .011 × tr. .014.

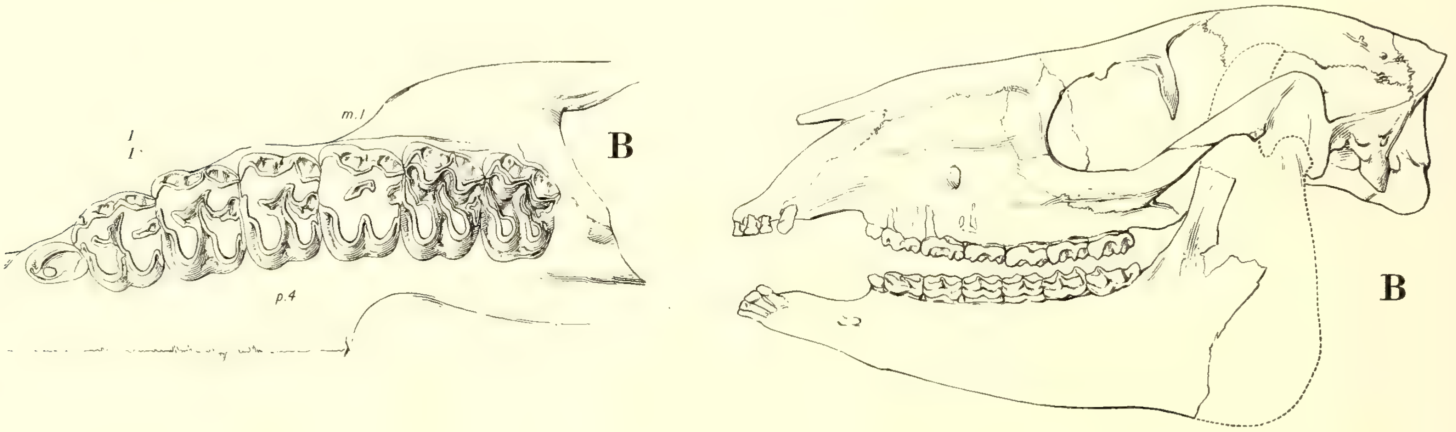

Fig. 26. *Mesohippus bairdii* Leidy, Amer. Mus. 1477, neotype (Osborn). After Osborn, 1904. (Left) Superior grinding teeth, fig. 3, p. 172; (right) skull, Pl. v, B. Skull one-half natural size, teeth natural size.

Type figure.— Text Fig. 25 of this Memoir.

Characters.—(Leidy, 1851, p. 122) Type. "This species is about two-thirds the size of P. crassum. The arrangement of the superior molars is very like that of Palæotherium Hippoides. . . . This second species Dr. L. named P. bairdii, in honor of Prof. S. F. Baird, Curator of the Smithsonian Institution."

Neotype.— (Osborn, 1904, p. 172) "A skull and skeleton, No. 1477 Amer. Mus. almost identical with Leidy's type, was found in the Lower Oreodon Beds of South Dakota."

Type and neotype characters.— (Osborn, 1904, 1918) (1) Skull with a distinct lachrymal fossa; (2) cranial (orbito-postorbital) region exceeds facial (preorbital) region in length; (3) molars with crests interrupted and moderately elevated; (4) small hypostyle present as a small bud or crest connected with posterior cingulum; (5) protoloph tending to unite with parastyle, interrupted by protoconule; (6) metaloph relatively sharp and continuous; (7) parastyle tending to connect with protoloph; (8) internal cingulum present in medivallum of m^3 only.

Mesohippus exoletus Cope, 1874. *Spec. indet.*

Anchitherium exoletum, Cope, spec. nov., Cope, E. D. "Report on the Vertebrate Paleontology of Colorado," *Ann. Rept. U. S. Geol. and Geogr. Surv. Terr. embr. Colorado* (for the year 1873), Washington, 1874, p. 496. No figure.

Horizon and locality.— "Miocene of Colorado" (Cope). Cedar Creek, Logan County, Colorado. Collected by E. D. Cope, 1873.

Type.— This type specimen has not been found in the Cope Collection. "Established on a portion of the right maxillary bone, which contains the last premolar and first premolar in perfect preservation and part of the third premolar." Measurements: "Length of fourth and fifth molars .0275, length of fourth molar .0140, width of fourth molar .0125, elevation of fourth molar .0080, length from front of malar to *foramen infraorbitale anterius* .0140."

Type figure.— No figure, as type has been lost.

Characters.— (Cope, 1874, p. 496) "....II. Anterior median tubercle well separated from inner: ....no inner basal lobes; crescents with concave outer faces....These teeth differ from the corresponding teeth in *A. bairdii* in many respects, resembling in the constitution of their outer lobes some of the symborodonts. The outer faces of these are uniformly concave to near the shoulder, leaving a very narrow basal ridge and no longitudinal median ridges. The intercrescentic ridge is incurved and not straight. The anterior middle tubercle is separated from the inner by a deep fissure and grooves to the base; the median is, on the other hand, continuous with the posterior inner. The posterior median is very small. The anterior and posterior basal ridges are small, and there is no trace of basal tubercle between the two medians. Enamel smooth. The size of this animal was probably that of the *A. bairdii,* but the molar teeth have the antero-posterior diameter greater in proportion to the transverse than in that species. The *foramen infraorbitale exterius* is over the front of the fourth premolar; it is above the front of the third in *A. bairdii.*"

The species is indeterminate. No specimen has been found in the American Museum Cope Collection agreeing with Cope's description.

Mesohippus cuneatus Cope, 1873. *Spec. indet.*

Anchitherium cuneatum sp. nov., Cope, E. D. "Third Notice of Extinct Vertebrata from the Tertiary of the Plains." *Palæontological Bull.* No. 16, privately printed, Aug. 20, 1873, 8 pp. (p. 7). No figure.

Horizon and locality.— Head of Cedar Creek, Logan County, Colorado. Probably from the Oreodon zone. Collected by E. D. Cope, 1873.

Type.— Am. Mus. Cope Coll. 6293. The type and cotype specimens are: upper jaws, milk teeth, dp$^{2-4}$, badly damaged, upper jaws (?) dp^{3}, m^{1} Am. Mus. Cope Coll. 6296; (?) dp^{4}, m^{1} Amer. Mus. Cope Collection 6285 are indeterminate (Matthew, 1915). Measurements: (Cope, 1873) No. 1 [type], "Length of M.2 and 3 .0260, length of M.1 .0130, width of M.1 0110; No. 2 [cotype], length of Ms. 1–4 .0410, length of M.2 .0115, width of M.2 .0130."

Type figure.— These types could not be identified when Cope's Colorado collection was catalogued by W. D. Matthew. As the type is probably lost or misplaced and there is no figure the species must be regarded as indeterminate.

Characters.— (Cope, 1873, p. 7) "Represented by the superior molar teeth of several individuals one-third smaller than those of the *A.* [*Mesohippus*] *bairdii.* The prominent peculiarity consists in the anterior production of the anterior external cusp anteriorly, giving a wedge-shaped outline to that part of the tooth. The first premolar is quite small. The fore and aft cingula are well developed, and the basal parts of the transverse ridges are partially separated into tubercles, the posterior one sending a low ridge backwards."

SPECIES ATTRIBUTED TO MIDDLE OREODON (METAMYNODON) ZONE 3.

Mesohippus trigonostylus sp. nov.

Plate 2.5,6. Text Fig. 27.

Horizon and locality.— Cheyenne River, Big Badlands, South Dakota, from the Metamynodon sandstones in the Middle Oreodon beds. Type collected by the American Museum Expedition of 1892 under Dr. J. L. Wortman.

Type.— Amer. Mus. 674, a complete superior grinding series, p^1–m^3 of the right side, adult. *Paratype,* Am. Mus. 673, an immature maxilla containing deciduous premolars and first molar, dp$^{1-4}$, m^1. Measurements may be taken from type figure.

Type figure.— Plate 2.6, text Fig. 27 of this Memoir.

Characters.— The specific name *M. trigonostylus* refers to the progressive triangular form of the plications of the hypostyle, which is highly distinctive. From the rudiment of the hypostyle on the post-cingulum, as seen in the *M. bairdii* stage, a cruciform plication extends anteriorly toward the metaloph, branching into an external pli hypostyle and an internal spur (see paratype, dp^4, Plate 2.5) which connects with the metaloph. This condition of the hypostyle is very different from that in any other Middle Oligocene species (compare Plate 2.1–8). A somewhat similar condition of the hypostyle is seen in the type of *Miohippus validus* from the Protoceras zone.

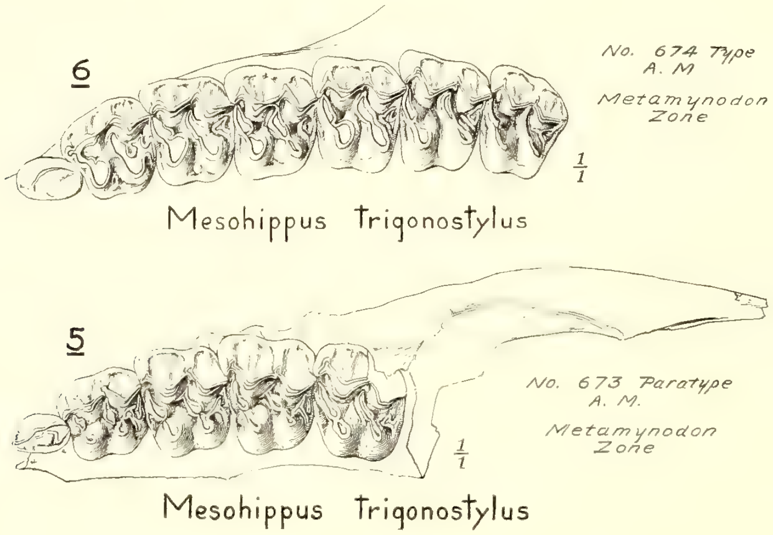

Fig. 27. (6) Type of *Mesohippus trigonostylus* Osborn, Amer. Mus. 674, adult dentition. (5) Amer. Mus. 673, paratype, milk dentition. Both figures natural size.

Mesohippus obliquidens Osborn, 1904.

Plates 1.5, 2.7. Text Fig. 28.

Mesohippus obliquidens, sp. nov., Osborn, Henry F. "New Oligocene Horses," *Bull. Amer. Mus. Nat. Hist.,* Vol. XX, Art. XIII, May 28, 1904, p. 173, fig. 4, Pl. v, C.

Horizon and locality.— Cheyenne River, Big Badlands of South Dakota, "from the nodular layer in lower middle layer of the Oreodon Beds; specimen covered with ferruginous oxide." Type collected by Amer. Mus. Expedition of 1892. Lower Oligocene, Middle Oreodon zone.

Type.— Amer. Mus. 668, skull and jaws. A young individual with three milk teeth *in situ.* Measurements: lower jaw from condyle to symphysis .149; m^1 a.p. .013, tr. .015.

Type figure.— Text Fig. 28 of this Memoir.

Characters.— (Osborn, 1904) "Distinguished from the other species of the Oreodon Beds by (1) large size of skull and teeth as compared with *M. bairdii,* (2) preorbital [lachrymal] fossa shallow or wanting, (3) but especially by the high crowns of upper and lower molars: ectoloph of m^1 measures .0105 vertical as compared with .008 in an unworn m^1 crown of *M. bairdi*[*i*], (4) metaloph elevated, metaconule not being clearly defined, (5) proto- and metalophs directed obliquely backward at a sharp angle with ectoloph, to which fact the name *M. obliquidens* refers." This is one of the horses of relatively larger size from the Upper Oreodon zone, possessing also relatively long-crowned molar grinding teeth.

The type is an immature specimen and the adult jaw would be larger than that of the cotype of *M. bairdii.* Matthew (1915) questions the validity of this species, regarding it as probably conspecific with *M. bairdii.*

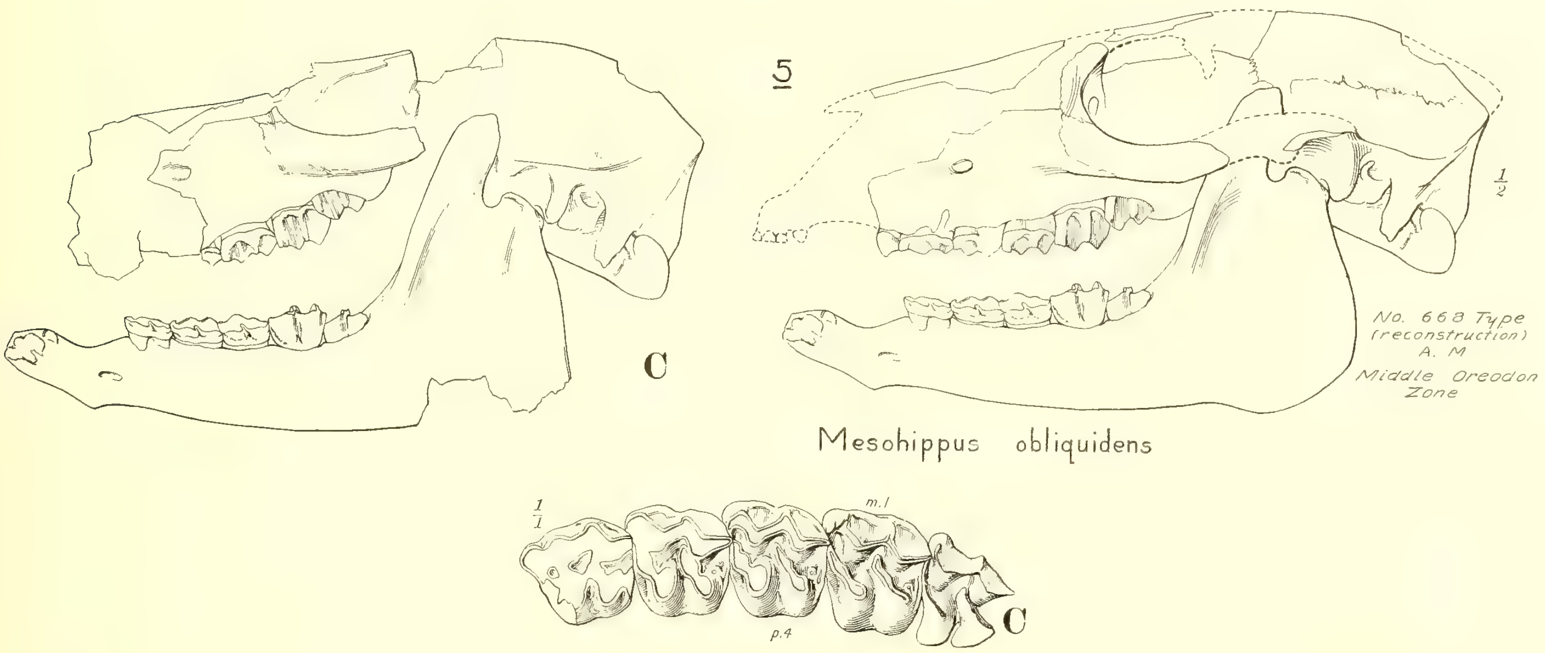

Fig. 28. Type of *Mesohippus obliquidens* Osborn, Am. Mus. 668. (Left) Original figures of type, after Osborn, 1904, Pl. v, C. (5) Side view of type skull, reconstructed in drawing. (Middle) Original figure of superior premolars, dp^{2-4}, and anterior molars, m^{1-2}, after Osborn, 1904, fig. 4, p. 173. Skulls one-half natural size, teeth natural size.

Species Attributed to Upper Oreodon Zone. 4.

Mesohippus eulophus Osborn, 1904.

Plates 1.6, 2.8. Text Fig. 29.

Mesohippus eulophus, sp. nov., Osborn, Henry F. "New Oligocene Horses," *Bull. Amer. Mus. Nat. Hist.*, Vol. XX, Art. XIII, May 28, 1904, pp. 173–4, fig. 5.

Horizon and locality.— Upper Oreodon zone (Horizon B) of Cedar Creek, Colorado. Type collected by F. B. Loomis, Am. Mus. Expedition of 1901.

Type.— Amer. Mus. 8791, a complete adult superior dental series of the left side and portion of cranium. Measurements: p^1–m^3 .076; m^{1-3} .036; m^1 a.p. .0115, tr. .015; m^3 a.p. .0123, tr. .015.

Type figure.— Plates 1.6, 2.8, text Fig. 29 of this Memoir.

Characters.— (Osborn, 1904) "Distinguished from *M. bairdi*[*i*] by (1) deep preorbital [lachrymal] fossa, which is deeper also than in *M. hypostylus;* (2) large size of m^3; (3) protoloph with very faint protoconule, and strongly connected with parastyle, constituting a nearly perfect anterior crest; metaloph also continuous; (4) as in *M. metculophus* m^1–m^3 exceed in linear measurement p^2–p^4; (5) p^4 slightly narrower than m^1; (6) series of grinding teeth, m^2–p^2, narrowing anteriorly."

Additional specific characters.— P^{2-4} of shorter length than p^{1-3}.

The name *eulophus* was assigned (Osborn, 1904, p. 173) in reference to the relatively perfect or continuous and uninterrupted condition of the transverse crests. The species was regarded as apparently ancestral to *Miohippus meteulophus* of the Leptauchenia zone and to *Hypohippus* of the Miocene. Matthew (1915) regards this as probably a subspecies or geographical variation of *Mesohippus bairdii.*

Colodon copei Osborn and Wortman, 1895.

Mesohippus copei, sp. nov., Osborn, H. F., and Wortman, J. L. "Perissodactyls of the Lower Miocene White River Beds," *Bull. Amer. Mus. Nat. Hist.* Vol. VII, Art. XII, Dec. 23, 1895, pp. 356–358, fig. 5.

Horizon and Locality.— Badlands near Cheyenne River, Protoceras zone, South Dakota. Type collected by American Museum Expedition, 1894.

Type.— Amer. Mus. 1197, a pelvis (also erroneously associated femur, tibia, and part of hind foot). The pelvis, the bone first mentioned belongs to some species of rhinoceros or lophiodon and is not that of a horse. The association of the other bones proves to have been erroneous. The femur does not belong with the pelvis. The identification of the tibia and astragalus has not been made; both bones are equine, however, and may be provisionally compared with *Miohippus crassicuspis.*

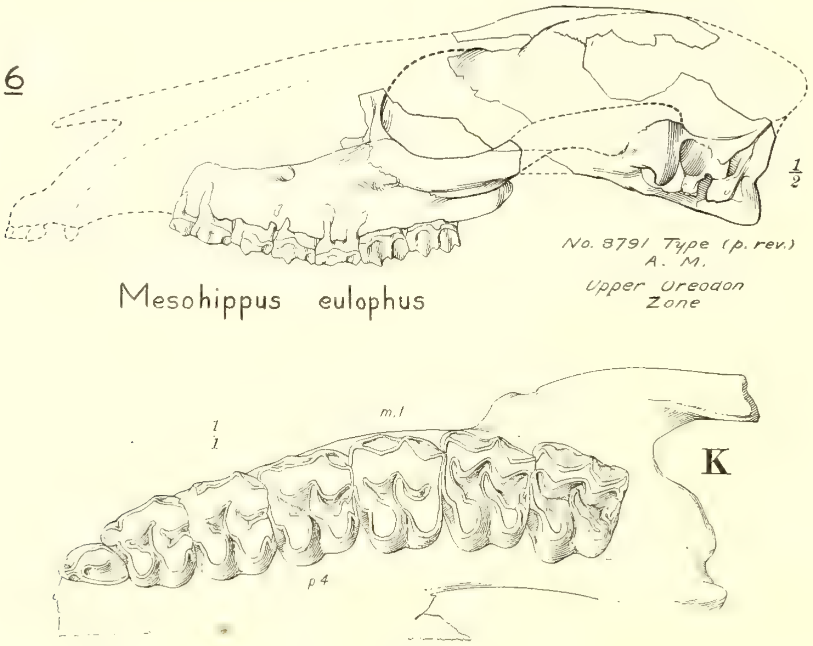

Fig. 29. Type of *Mesohippus eulophus* Osborn, Am. Mus. 8791. (K) Original figure of left maxilla of type, containing p^1–m^3. Natural size. After Osborn, 1904, fig. 5, p. 174. (6) Side view of type skull, partly reversed in drawing. One-half natural size.

The premolars, Am. Mus. 683, provisionally referred to this species by Osborn and Wortman (1895, p. 357, fig. 5) do not belong to the genus *Colodon* but represent a large equine with interrupted crests, renamed *Miohippus crassicuspis* by Osborn in 1904.

GENUS **MIOHIPPUS** Marsh, 1874.

Amer. Jour. Sci. and Arts, (3), Vol. VII, Mar. 1874, pp. 249–250.

Genotype.— *Miohippus annectens* Marsh, type probably from Upper John Day, Oregon.

The generic stage *Miohippus* and the related *Kalobatippus* embrace twenty species described between 1871 and 1918, including six species transferred from *Mesohippus,* six species transferred from *Anchitherium,* as shown in the table below.

As will be observed in a comparison of Plates 1–3, the line between such species as *Miohippus* (*Mesohippus*) *meteulophus* and *M. brachystylus* of the Leptauchenia zone and *M.* (*Mesohippus*) *intermedius* of the Protoceras zone is purely arbitrary. It is obvious that members of more than one phylum are passing from one genus into the next, and *Mesohippus meteulophus* and *M. brachystylus* may with equal consistency be referred to *Miohippus.*

The geologic range of *Miohippus* is through the Protoceras zone of the Big Badlands of South Dakota, probably also certain levels of the Leptauchenia zone in the same region, into the Diceratherium zone or Middle John Day of Oregon and up into the Promerycochoerus zone of the Upper John Day of Oregon also into the Lower Rosebud formation (*Miohippus equinanus, M. gemmarosæ*) of Pine Ridge, South Dakota. The various species have not as yet been compared in sufficient detail to separate the phyla; in fact, the species themselves require much condensation.

The chief stages of *character genesis and evolution* and of *proportional evolution* observed in the fifteen species at present referred to *Miohippus* are as follows:

1. Premolars $\frac{2-4}{2-4}$ typically exceed in length molars $\frac{1-3}{1-3}$.
2. P^4 typically exceeds m^1 in width.
3. Cranial exceeds facial region in length (*M. intermedius, M. validus, ?M. gidleyi*); facial exceeds cranial region in length in *M. meteulophus, M. brachystylus,* also in all more progressive stages of the Equidæ.
4. Grinding teeth with internal cingulum absent or reduced (*M. gidleyi*).
5. Lophs of the bunolophoid or lophoid types.
6. Hypostyle large, typically angular, more or less separate from post-cingulum.
7. A rudimentary crochet in *M. gidleyi* and *M. equinanus.*
8. A relatively deep lachrymal fossa or a relatively broad, shallow lachrymo-malar fossa.
9. Pes more progressive, a Mts. III-cuboid facet.

LEPTAUCHENIA-PROTOCERAS-MIOHIPPUS ZONE. 5. UPPER OLIGOCENE.

As described in the geologic section, this important and distinct zone is distributed in South Dakota, North Dakota, and Montana. It is distinguished by the presence of a variety of species, all of which are referred to the *Miohippus* stage.

Miohippus meteulophus Osborn, 1904.

Plates 1.7, 3.1. Text Fig. 30.

Mesohippus meteulophus, sp. nov., Osborn, Henry F. "New Oligocene Horses," *Bull. Amer. Mus. Nat. Hist.* Vol. XX, Art. XIII, May 28, 1904, pp. 167–179, figs. 1–8, Pl. v. pp. 174–5, Pl. v, D.

Horizon and locality.— Big Badlands of South Dakota, Leptauchenia zone, Upper Oligocene. Type collected by Am. Mus. Expedition of 1894.

Type.— Amer. Mus. 1210, adult skull and jaws. Measurements: basilar length, occipital condyles to premaxillaries .215; p^1–m^3 .078; m^{1-3} .038; m^1 a.p. .013, tr. .017.

Type figure.— Text Fig. 30 of this Memoir.

Characters.— (Osborn, 1904, p. 174) "This species is a successor of *M. eulophus,* from which it is distinguished (1) by its decidedly more elongate or hypsodont molar crowns, the crests being .002 higher; (2) by its larger size; (3) unlike

I. Type Descriptions of the Species of Miohippus in Chronologic Order.

Date	Original name and author	Present reference	Locality	Life zone
1870	*Anchitherium condoni* Leidy	*Miohippus condoni*	Bridge Creek, Ore.	Promerycochœrus-Miohippus zone
1874.1	*Miohippus annectens* Marsh	“ *annectens*	John Day Series, Oregon	“ “ “
1874.2	*Anchitherium anceps* Marsh	“ *anceps*	“ “ “ “	Diceratherium- “ “
1878.1	“ *equiceps* Cope	“ *equiceps*	“ “ “ “	“ “ “
1878.2	“ *brachylophum* Cope	“ *brachylophus*	“ “ “ “	“ “ “
1878.3	“ *longicristis* Cope	“ *longicristis*	“ “ “ “	“ “ “
1895	*Mesohippus intermedius* Osborn and Wortman	“ *intermedius*	Big Badlands, So. Dak.	Miohippus-Protoceras zone
1904.1	“ *meteulophus* Osborn	“ *meteulophus*	“ “ “ “	Leptauchenia zone
1904.2	“ *brachystylus* Osborn	“ *brachystylus*	“ “ “ “	“ “
1904.3	“ *validus* Osborn	“ *validus*	“ “ “ “	Miohippus-Protoceras zone
1904.4	“ *gidleyi* Osborn	“ *gidleyi*	“ “ “ “	“ “ “
1904.5	*Miohippus crassicuspis* Osborn	“ *crassicuspis*	“ “ “ “	“ “ “
1905	*Mesohippus acutidens* Sinclair	“ *acutidens*	John Day Series, Oregon	Promerycochœrus-Miohippus zone
1918.1	*Miohippus primus* Osborn	“ *primus*	“ “ “ “	Diceratherium- “ “
1918.2	“ *quartus* Osborn	“ *quartus*	“ “ “ “	“ “ “
1918.3	“ *equinanus* Osborn	“ *equinanus*	Porcupine Creek, So. Dak.	Promerycochœrus-Miohippus zone
1918.4	“ *gemmarosæ* Osborn	“ *gemmarosæ*	Bear-in-Lodge Creek, So. Dak.	“ “ “

II. Types as Recorded or Inferred in 1917 in Geologic Succession.

Date	Species, Present reference	Life zone	Formation, Beds	Locality	Age
1918.4	*Miohippus gemmarosæ* Osborn	Promerycochœrus-Miohippus zone	Lower Rosebud formation	Bear-in-Lodge Creek, So. Dak.	Upper Oligocene
1918.3	“ *equinanus* Osborn	“ “ “	“ “ “	Porcupine Creek, So. Dak.	“ “
1905	“ *acutidens* Sinclair	“ “ “	Upper John Day “	John Day Series, Oregon	“ “
1874.1	“ *annectens* Marsh	“ “ “	?Upper “ “ “	“ “ “ “	“ “
1870	“ *condoni* Leidy	? “ “ “	“ “ “ “	Bridge Creek, Oregon	“ “
1918.2	“ *quartus* Osborn	Diceratherium- “ “	Middle “ “ “	John Day Series, Oregon	“ “
1918.1	“ *primus* Osborn	“ “ “	“ “ “ “	“ “ “ “	“ “
1878.3	“ *longicristis* Cope	“ “ “	“ “ “ “	“ “ “ “	“ “
1878.2	“ *brachylophus* Cope	“ “ “	?Middle “ “ “	“ “ “ “	“ “
1878.1	“ *equiceps* Marsh	“ “ “	“ “ “ “	“ “ “ “	“ “
1874.2	“ *anceps* Marsh	“ “ “	Middle “ “ “	“ “ “ “	“ “
1904.5	“ *crassicuspis* Osborn	Miohippus-Protoceras zone	Brule (upper) “	Big Badlands, So. Dak.	“ “
1904.4	“ *gidleyi* Osborn	“ “ “	“ “ “	“ “ “ “	“ “
1904.3	“ *validus* Osborn	“ “ “	“ “ “	“ “ “ “	“ “
1895.1	“ *intermedius* Osborn	“ “ “	“ “ “	“ “ “ “	“ “
1904.2	“ *brachystylus* Osborn	Leptauchenia-Miohippus zone	“ “	“ “ “ “	“ “
1904.1	“ *meteulophus* Osborn	“ “ “	“ “	“ “ “ “	“ “

M. eulophus p^4 is broader than m^1, a progressive stage towards the equine condition; (4) it accents the *M. eulophus* character of the heavy but continuous meta- and protolophs which are not distinctly interrupted by conules. In the ectoloph the parastyle, mesostyle, and ribs are sharply defined but not prominent, in fact, the ectoloph is somewhat flattened. (5) Another feature is that the protoloph is more elongate transversely than the metaloph, causing these crests to be somewhat asymmetrical as in *M. latidens*."

Additional characters.— (Osborn, 1918) (6) P$^{2-4}$ of less length than m$^{1-3}$, *i. e.* Pms.$<$Ms. (7) Facial (preorbital) region exceeds cranial (orbito-postorbital) region in length.

While more progressive than *M. intermedius* in its high specific characters (1–5) *M. meteulophus* is sharply distinguished as follows: (8) the hypostyle rises directly on the posterior cingulum; it is not in the least separate; (9) it differs from *M. gidleyi* in the conformation of the crests, the small size of p^2, and the relatively large size of m^3; (10) as in *Hypohippus* the external cingulum tends to cross the base of the parastyle; (11) the crests are relatively simple and continuous; (12) postfossette partly indicated in the premolars; (13) lachrymal fossa vertically narrow, long and deep, extending down into malar region; (14) parastyle flattened or angulate.

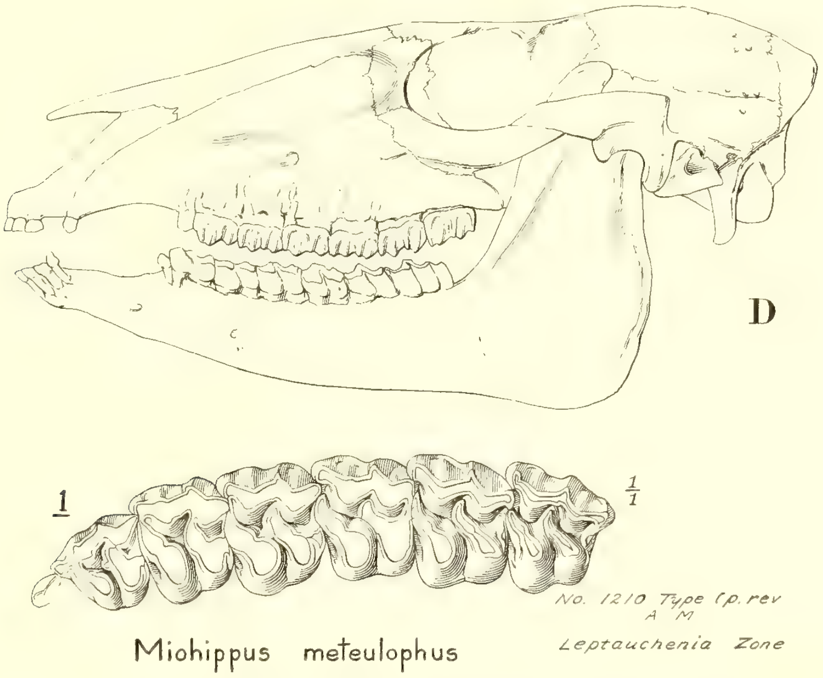

Fig. 30. Type of *Miohippus meteulophus* Osborn, Amer. Mus. 1210. (D) Original figure of type. One-half natural size. After Osborn, 1904, Pl. v, D. (1) Superior molars of type, partly reversed in drawing. Natural size.

Matthew (1915) regards these resemblances as pointing not especially toward *Hypohippus* but equally toward *Archæohippus* or certain species of *Parahippus*.

Miohippus brachystylus Osborn, 1904.

Plates 1.8, 3.2. Text Fig. 31.

Mesohippus brachystylus sp. nov., Osborn, Henry F. "New Oligocene Horses," *Bull. Amer. Mus. Nat. Hist.* Vol. XX, Art. XIII, May 28, 1904, pp. 175–176, fig. 6, Pl. v, E.

Horizon and locality.— Big Badlands of South Dakota, near Cheyenne River, Leptauchenia zone. Type collected by H. F. Wells, 1903.

Type.— Amer. Mus. 11860, posterior portion of facial and cranial region of skull with complete upper dental series of left side, adult. Measurements: p^1–m^3 .082; m$^{1-3}$ .038; m^1 a.p. .0135, tr. .0175; m^3 tr. .0155.

Type figure.— Text Fig. 31 of this Memoir.

Characters.— (Osborn, 1904, 1917) The name refers (1) to the broad rounded parastyle, readily distinguishable from the flattened angulate parastyle of *Mesohippus eulophus, Miohippus meteulophus,* and *Hypohippus.* This species is further distinguished by: (2) p^{2-4} exceeding m^{1-3} in length (the reverse occurs in *M. eulophus*); (3) broadly depressed proto- and metalophs; (4) protoloph interrupted, with large oval protocone and distinct protoconule uniting externally with parastyle as in *M. bairdii;* (5) ectoloph with broad, prominent, rounded parastyle and well defined mesostyle, para- and metacone ribs defined; (6) hypostyle connected with cingulum but giving off a strong outward spur. (7) A vertically broad, shallow lachrymo-malar fossa (as compared with the narrow fossa in *M. meteulophus*); (8) facial exceeds cranial length.

(Osborn, 1904) This horse, which is an animal of larger size than *Mesohippus bairdii,* appears to be one of its successors although of larger size. In some respects it appears to be ancestral to the type of *Miohippus intermedius* of the Protoceras zone, connected by a simpler intermediate stage (Amer. Mus. 1218). The molars approach the buno-selenodont type, with resemblances to those of *Miohippus crassicuspis, M. anceps,* etc.

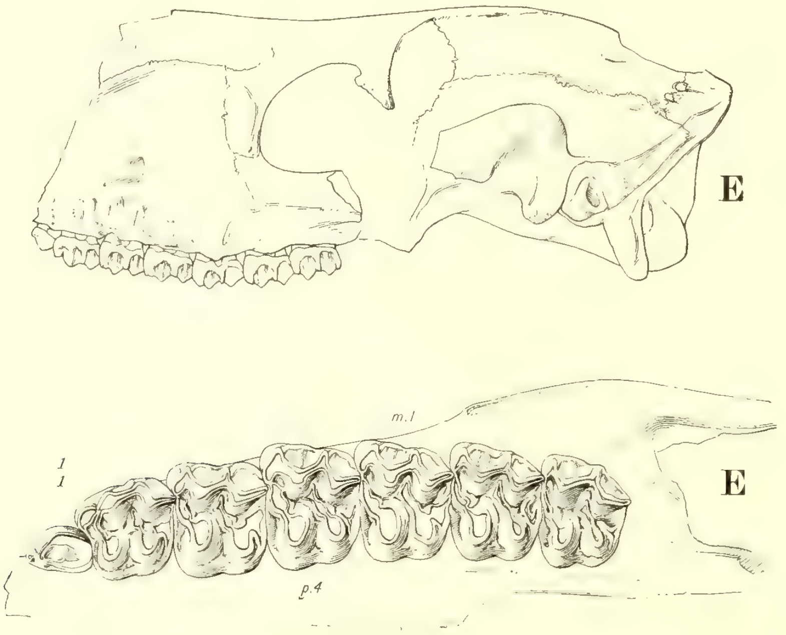

Fig. 31. Original figures of type of *Miohippus brachystylus* Osborn, Amer. Mus. 11860. (Upper) Lateral view of skull, one-half natural size. (Lower) Crown view of superior grinding teeth, p^1–m^3, of the left side. Natural size. After Osborn, 1904, skull Pl. v, E, teeth fig. 6, p. 175.

Miohippus intermedius Osborn and Wortman, 1895.

Plates 1.9, 3.3. Text Fig. 32.

Mesohippus intermedius, sp. nov., Osborn, H. F., and Wortman, J. L., "Perissodactyls of the Lower Miocene White River Beds," *Bull. Amer. Mus. Nat. Hist.* Vol. VII, Art. XII, Dec. 23, 1895, p. 355, fig. 4.

Horizon and Locality.— Badlands near Cheyenne River, South Dakota, Protoceras zone. Type collected by American Museum Expedition, 1894.

Type.— Amer. Mus. Nat. Hist. 1196, skull and parts of skeleton. Measurements: basilar length, condyles to symphysis .218; p^1–m^3 .088; m^{1-3} .040; m^1 a.p. .0135, tr. .018.

Type figure.— Text Fig. 32 of this Memoir.

Characters.— (Osborn and Wortman, 1895, Osborn, 1918) (1) Skull with large and apparently undivided lachrymo-malar fossa of the shallow vertically broad type: (2) cranial exceeds facial length. (3) Premolars 3–4 exceeding molars in width; (4) premolars 2–4 exceeding molars 1–3 in length; (5) molars bunoselenodont in character, lophs interrupted, protocone large; (6) hypostyle separate and distinct or only slightly connected with posterior cingulum, in some specimens (*e. g.* American Museum 1043) still partly connected. Despite the foregoing progressive characters, (7) protoloph decidedly interrupted by protoconule; (8) molars more brachyodont than in *M. meteulophus;* (9) parastyle broad and rounded when worn, as in *M. brachystylus* and *M. bairdii.* (10) A characteristic feature of this species is the long and rather slender metapodials combined with *short* phalanges; leads up into *Kalobatippus.*

To this species is also referred a palate, Amer. Mus. 1043, which exhibits the same characters.

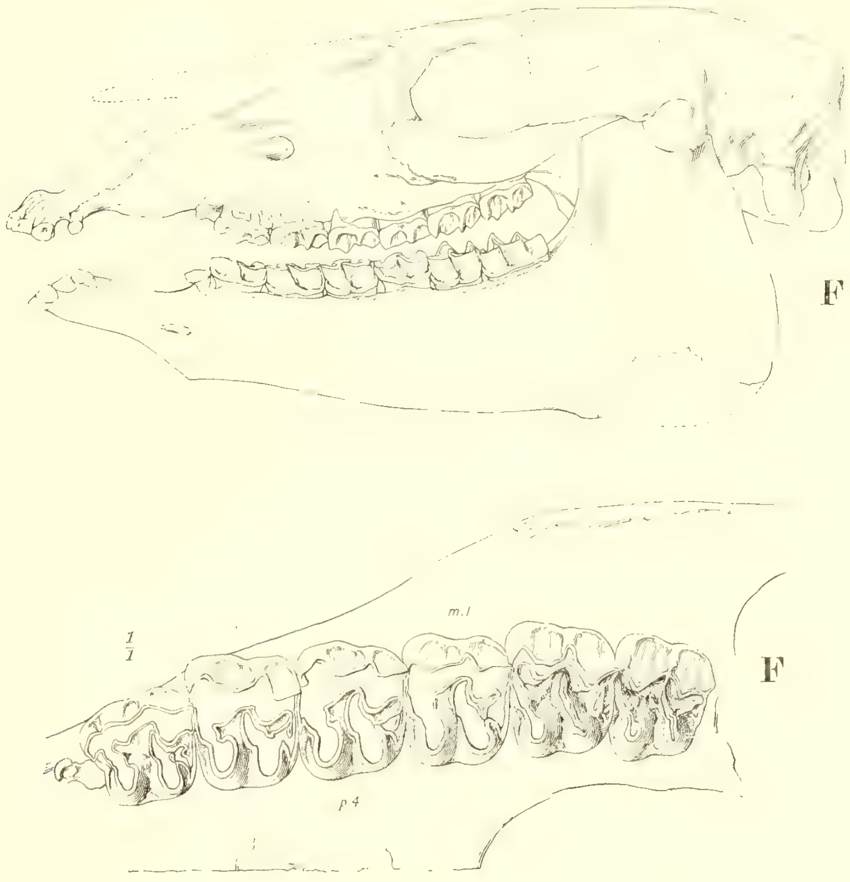

Fig. 32. *Miohippus intermedius* Osborn and Wortman, Am. Mus. 1196. (Upper) Original figure of skull of type. One-half natural size. (Lower) Original figure of left upper molars of type. Natural size. After Osborn, 1904, skull Pl. v, F, teeth fig. 7, p. 176.

Miohippus validus Osborn, 1904.

Plates. 1.4, 3.5. Text Fig. 33.

Mesohippus validus, sp. nov., Osborn, Henry F. "New Oligocene Horses," *Bull. Amer. Mus. Nat. Hist.*, Vol. XX, Art. XIII, May 28, 1904, p. 177, Pl. v, H.

Horizon and Locality.— Big Badlands, Cheyenne River, South Dakota, Protoceras zone. Type collected by American Museum Expedition, 1894.

Type.— Amer. Mus. 1218, skull and jaws and portions of limbs. Measurements: p^1–m^3 .104; m^{1-3} .047; m^1 a.p. .0165, tr. .021; basilar length, condyles to premaxillary symphysis. .250+.

To this type is also referred the adult skull Amer. Mus. 680 with well worn teeth; also the skull Princeton Mus. 10733.

Type figure.— Text Fig. 33 of this Memoir.

Characters.—(Osborn, 1904, p. 177, 1917) P^{2-4} apparently less than molars m^{1-3} in length; (2) ectoloph elevated, height .013; (3) parastyle broad, paracone and metacone ribs distinct; (4) metaloph short or else separated from ectoloph; (5) protoloph interrupted, protocone indented; (6) the hypostyle < shaped or triangular, connected with cingulum and with a strong outward spur. (7) Lachrymo-malar fossa relatively deep and vertically broad, subdivided by a low median ridge into anterior and posterior depressions; (8) cranial exceeds facial length. As compared with *Mesohippus bairdii* this animal is a relatively large horse, standing not less than twenty-eight inches at the withers.

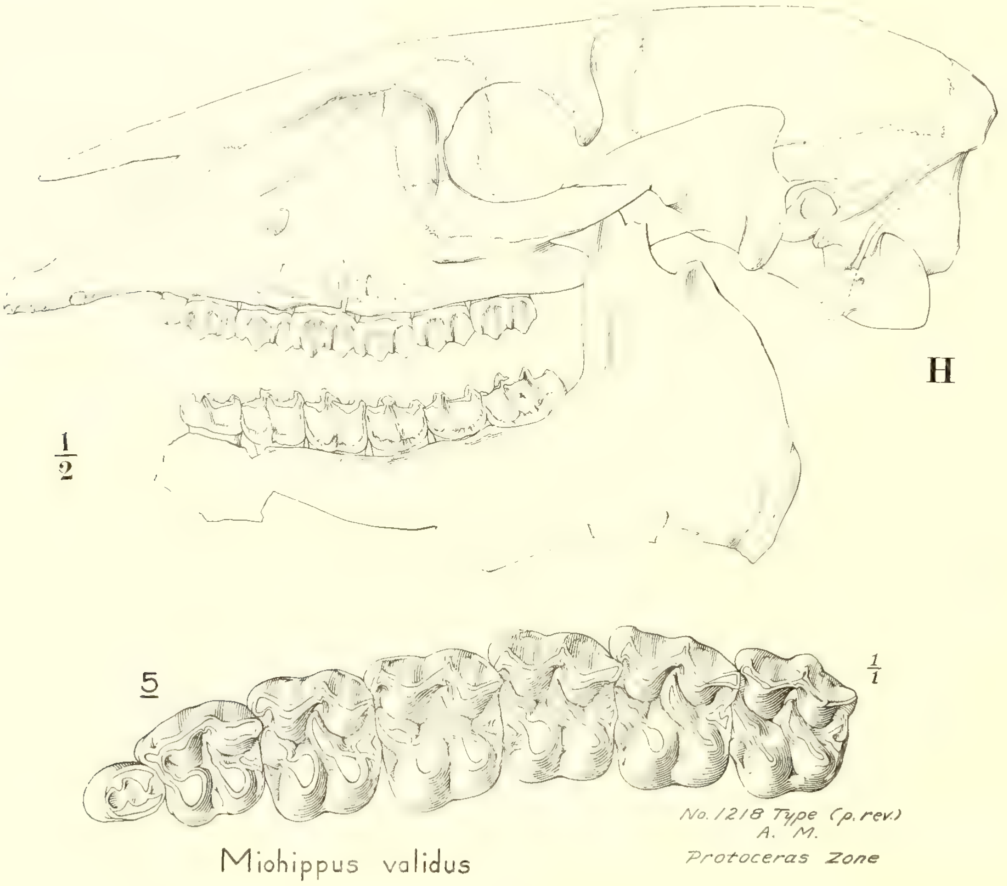

Fig. 33. *Miohippus validus*, Osborn, Am. Mus. 1218. (H) Original figure of skull of type, exhibiting the vertically deep lachrymo-malar fossa; cranial exceeding facial length. One-half natural size. After Osborn, 1904, Pl. v, H. (5) Crown view of superior molar-premolar teeth of type. Natural size.

Miohippus gidleyi Osborn, 1904.

Plates 1.10, 3.4, 39.16,19, 51.8,12. Text Fig. 34.

Mesohippus gidleyi, sp. nov., Osborn, Henry F., "New Oligocene Horses," *Bull. Amer. Mus. Nat. Hist.*, Vol. XX, Art. XIII, May 28, 1904, p. 178, fig. 8, Pl. v G.

Horizon and locality.— Badlands near Cheyenne River, South Dakota, Protoceras zone. Type collected by American Museum Expedition of 1894.

Type.— Amer. Mus. 1192, partly broken skull of young individual, with complete unworn grinding teeth, cervical vertebræ associated. Measurements: P^1–m^3 .0975; m^{1-3} .042; m^1 a.p. .0145, tr. .019.

Type figure.— Text Fig. 34 of this Memoir.

Characters.— (Osborn, 1904, p. 178, 1918) (1) An animal of somewhat larger size than the type of *Miohippus intermedius*, which, however, it resembles in the presence of (2) a vertically deep lachrymo-malar fossa, and (3) in the sharpness of the metaloph crest of the molars. It is more primitive than *M. intermedius* in (4) the somewhat larger size of p^1. (5) Hypostyle and transverse crest still connected with posterior cingulum, a distinct pli hypostyle; (6) internal cingulum persisting, especially evident on the premolars; (7) ectoloph more elevated than metaloph. Other special characters which appear to be distinctive are (8) the crenulation of the enamel surface of the premolars, and (9) a rudimentary spur or crochet, pli crochet, on the metaloph of p^3, m^2; (10) external cingulum tending to cross base of parastyle; (11) protoloph longer than metaloph in the premolars.

A rudimentary crochet observed in *M. gidleyi* is also seen in m^3 of *M. intermedius.*

This species appears to be confirmed by a referred specimen, Princeton Mus. 10501, which is slightly more progressive.

It is named in honor of J. W. Gidley, the leading explorer for fossil horses under the William C. Whitney Fund of the American Museum of Natural History.

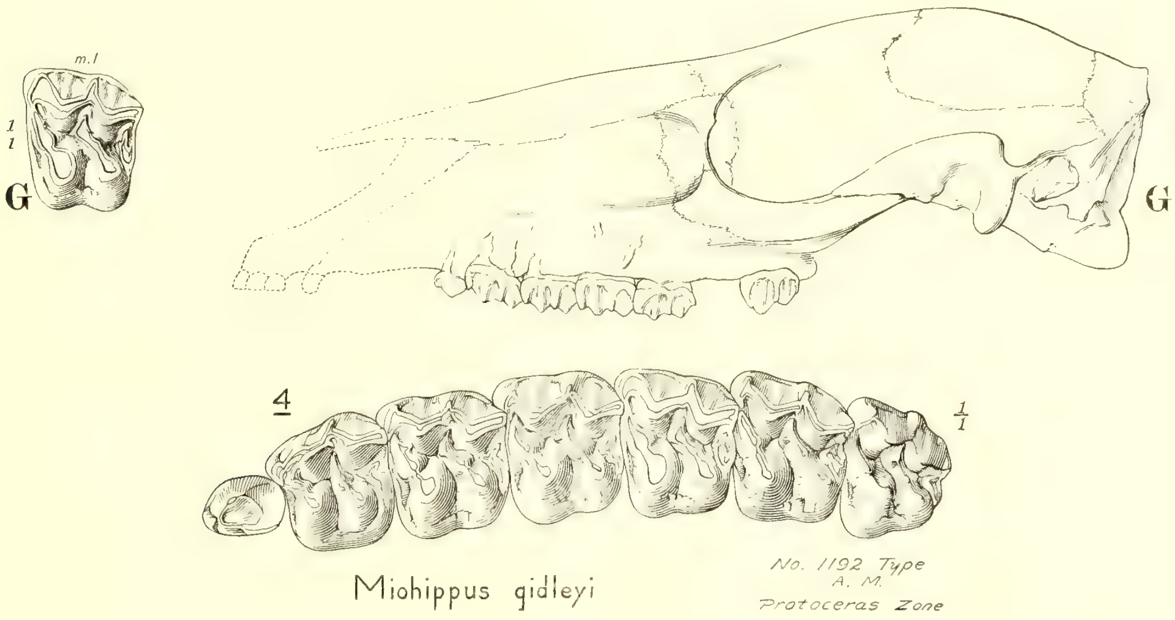

Fig. 34. *Miohippus gidleyi* Osborn, Am. Mus. 1192. (Right upper) Original figure of skull of type. One-half natural size. (Left upper) Original figure of crown of m^1 of type. Natural size. After Osborn, 1904, skull Pl. v, G, tooth fig. 8, p. 178. (4) Crown view of superior molar-premolar series of type. Natural size.

Miohippus crassicuspis Osborn, 1904.

Plate 3.11. Text Fig. 35.

Miohippus crassicuspis, sp. nov., Osborn, Henry F. "New Oligocene Horses," *Bull. Amer. Mus. Nat. Hist.*, Vol. XX, Art. XIII, May 28, 1904, pp. 178–179, no figure.

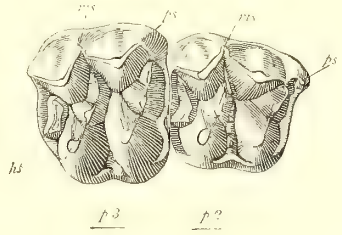

Fig. 35. Original figure of type *Miohippus crassicuspis* Osborn, Amer. Mus. 683, p^{2-3} of the right side. Natural size. After Osborn, 1895, fig. 5, p. 357.

The teeth represented in this figure when first published (Osborn and Wortman, 1895, fig. 75, p. 357) were mistakenly referred to *Mesohippus* (= *Colodon*) *copei.*

Horizon and locality.— Big Badlands, Cheyenne River, South Dakota, Protoceras zone. Type collected by American Museum Expedition of 1892.

Type.— Amer. Mus. 683. Second and third right upper premolars. Measurements: p^{2-3} .035.

Type figure.— Plate 3.11, text Fig. 35 of this Memoir.

Characters.— (Osborn, 1904, p. 179, 1918) (1) Type premolars belong to an animal of larger size than the types of *M. intermedius, M. validus*, or *M. gidleyi.* (2) Much interrupted transverse crests of the premolars, the cones and conules quite distinct and separate, a character to which the specific name *M. crassicuspis* refers; (3) internal cingulum strong but not continuous; (4) in the medivallum are low transverse ridges which rise into cuspules in the related species *M. annectens;* (5) sides of the protoloph and metaloph crenulate as in *M. gidleyi;* (6) hypostyle a strong transverse crest nearly separated from posterior cingulum; (7) external cingulum tending to surround parastyle.

The type teeth were at first mistakenly associated with a pelvis of *Colodon* (*Mesohippus*) *copei;* they are now found to resemble most closely those of *Miohippus annectens* Marsh from the John Day beds.

DICERATHERIUM-MIOHIPPUS ZONE. 6. LATE UPPER OLIGOCENE.

THIS ZONE IS TYPIFIED IN THE MIDDLE JOHN DAY OF OREGON, WHICH CONTAINS LARGE AND PROGRESSIVE SPECIES OF *MIOHIPPUS*.

Miohippus anceps Marsh, 1874.

Text Fig. 36.

Anchitherium anceps, sp. nov., Marsh, O. C. "Notice of New Equine Mammals from the Tertiary Formation, "*Am. Jour. Sci. and Arts* (3), Vol. VII, No. 39, Mar. 1874, p. 250. No figure.

Horizon and locality.— "Miocene deposits of Oregon." (?Middle) John Day formation, Diceratherium zone. In the Yale Museum catalogue, "John Day Valley Cove, Ore., T. Condon collector and donor." "The Cove" is a locality on the John Day River. Most of the material collected from it is Middle John Day.

Type.— Yale Mus. 11285. (Marsh, 1874, p. 250). Type specimens not designated in type description. (Lull, R. S., letter October 23, 1915): "I can only identify part of this type, consisting of the left maxilla with premolars 1–4, the back end of the right mandible with molars 2 and 3, with a gray matrix. Marked '*Anchitherium anceps* type.' John Day Valley (Cove) Ore. *T. Condon* collector and donor. Catalogue number 11285." Measurements: (Marsh, 1874) p^{1-4} .0475; p^4 a.p. .013, tr. .0155; m_3 a.p. .017, tr. .008. In cotype (second specimen) p^1–m^3 .082; m^{1-3} .037.

Type figure.— The new type figure (text Fig. 36) represents the first specimen mentioned in Marsh's description.

Characters.— (Marsh, p. 250) The author observed that the remains of this species indicate (1) an animal about as large as a sheep. (2) It differs from *Mesohippus* (*A.*) *bairdii* in its larger size. (3) The limbs so far as known are similar to those of *Anchitherium.* (4) Skull has a large antorbital fossa; (5) skull depressed between the orbits; (6) the antorbital foramen is above the centre of the third premolar; (7) Malar extending farther back below the orbit. (8) Lower teeth agree essentially with those of *Anchitherium;* (9) external cusps of upper molars with stouter buttresses; (10) concavities between them divided by more prominent vertical ridges. (Lull, letter October 23, 1915) "Marsh's description of *Anchitherium anceps* calls for more data than this specimen [Type, Yale Mus. 11285] can furnish. One second skull (green matrix) which could have been seen by him does not tally accurately with his description though I have always supposed it to be *A. anceps.*"

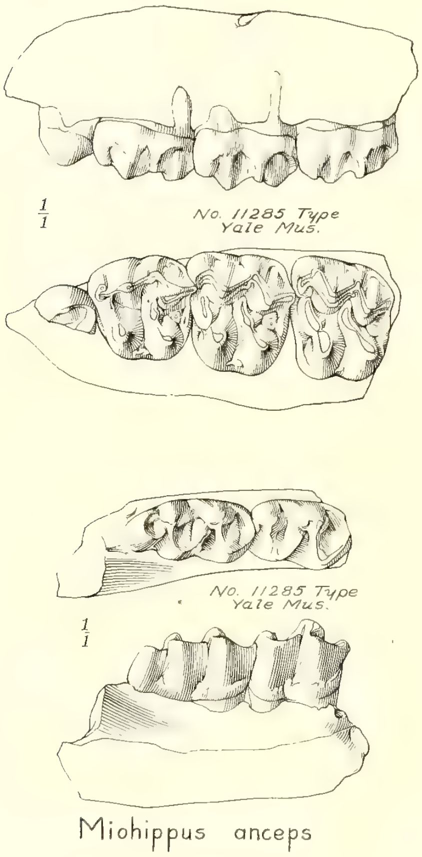

Fig. 36. Type of *Miohippus anceps* Marsh, Yale Museum 11285, p^{1-4} of left maxilla, m_{2-3} of right mandible. Natural size.

(Osborn, 1917) From these notes by Lull it appears that the characters of *Miohippus anceps* rest on the type specimen. The association of the second specimen (skull) is somewhat doubtful.

Miohippus equiceps (Cope) 1878.

Plates 3.10, 5.4,5, 6.1. Text Fig. 37.

Anchitherium equiceps, sp. nov., Cope, E. D. "On Some of the Characters of the Miocene Fauna of Oregon," *Proc. Amer. Philos. Soc.*, Vol. XVIII, 1878–1880 (sig. dated Dec. 26, 1878), p. 73, no figure. *Palæontological Bull.* No. 30, "Dec. 3, 1878."

Horizon and Locality.— Miocene of Oregon, horizon probably Middle John Day, Diceratherium zone.

Type.— Amer. Mus. 7261. Skull and jaws. (Cope) "This animal is represented by a portion of the skeleton including the complete cranium of one individual with [cotypes] mandibular rami of several others." Measurements: (Cope) total length of cranium .280; length of molar series .100; length of premolars .053; m^1 a.p. .0135, tr. .0165; m^3 a.p. .0135, tr. .0170.

Type figure.— Plates 3.10, 5.5, 6.1, text Fig. 37 of this Memoir.

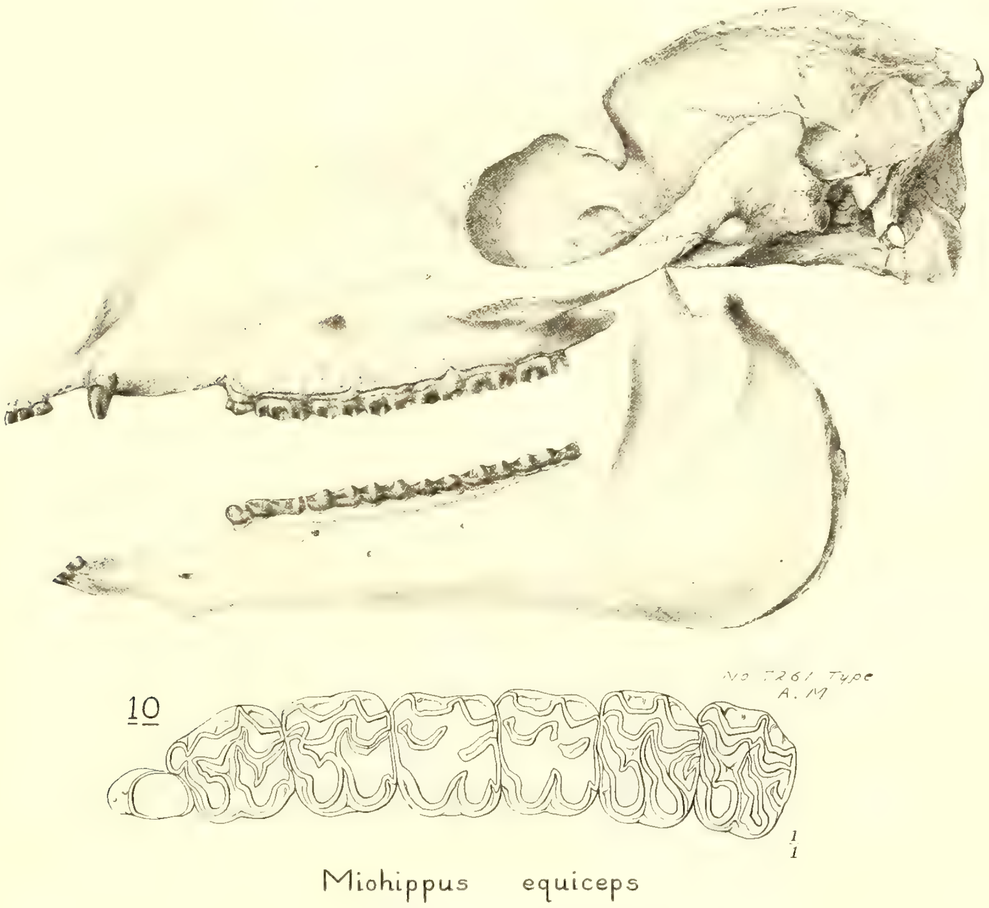

Fig. 37. (Upper) Type of *Miohippus equiceps* Cope, Amer. Mus. Cope Coll. 7261. One-half natural size. Drawing by B. Yoshihara. (Lower) Superior molar-premolar series of type. Natural size.

Characters.— (Cope, 1878, pp. 73, 74) (1) Preorbital region but little concave; (2) anterior border of orbit above posterior half of first true molar. (3) Molars with a tubercle between the anterior lobes; (4) a weak cingulum around inner base of protoloph; (5) p^2 with cingulum around protoloph and metaloph; (6) a large three-sided hypostyle; (7) external basal cingulum robust; (8) para- and metacones with median ridges well marked. (9) It differs from the type of *Miohippus* (*A.*) *condoni* in the presence of median internal tubercle and cingulum, and (10) also in the presence of a trihedral instead of a linear hypostyle.

(Matthew, 1913) (11) Lachrymal fossa shallow; (12) infraorbital foramen above posterior end of p^3; (3) tubercle in medivallum; (14) m^3 slightly smaller than m^{1-2}; (15) distinct cusp on anterior border of cingulum; (16) lower dentition shows strong crest on outer side of hypoconulid of m_3.

Miohippus brachylophus Cope, 1878.

Plates 3.9, 5.3. Text Fig. 38.

Anchitherium brachylophum, sp. nov., Cope, E. D. "On Some of the Characters of the Miocene Fauna of Oregon," *Proc. Amer. Philos. Soc.* Vol. XVIII, 1878–1880 (sig. dated Dec. 26, 1878), pp. 74, 75, no figure. *Palæontological Bull.* No. 30," Dec. 3, 1878."

Horizon and Locality.—(Cope) "Miocene of Oregon." Horizon, (?) Middle John Day, Diceratherium zone. Name of collector not given.

Type.—Amer. Mus. Cope Coll. No. 7260. (Cope) "Portions of maxillary bones supporting molar teeth." A fragment of the upper jaw with m^{1-2}. Measurements: (Cope) length of m^{1-2} .030; m^1 a.p. .015, tr. .017; dimensions same as those of *M. equiceps*.

Type figure.—Text Fig. 38 of this Memoir.

Characters.—(Cope, 1878) "The median and inner tubercles are not deeply separated, and the former are cut off from the external crescents by a deep fissure. There is no tubercle between the bases of the inner cones, nor is there any internal cingulum. The anterior cingulum does not develop a distinct tubercle, and does not extend to the anterior extremity of the anterior outer crescent. The posterior cingulum develops a large trihedral tubercle, and then extends nearly to the external crescent. The external cingulum is robust, and the external columns are prominent; the intervening spaces are impressed, and have a distinct median ridge. Enamel smooth or slightly regose at base of crown."

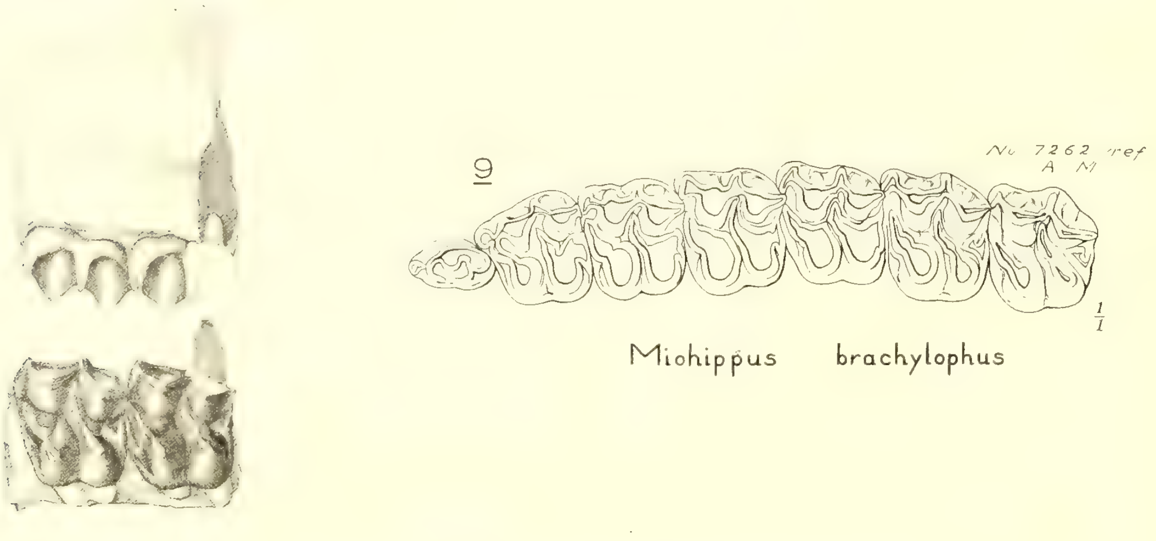

Fig. 38. *Miohippus brachylophus* Cope. (Left) Amer. Mus. Cope Coll. 7260, type, m^{1-2} of the left side, crown and side views. (Right) Amer. Mus. 7262, referred specimen, crown view of superior molar-premolar series of the left side. All figures natural size. Drawing by B. Yoshihara.

(Matthew, 1913) (1) No cingulum around protocone; (2) no basal cusp in medivallum; (3) no distinct cusp on the anterior cingulum; (4) parastyle on p^2 less prominent than type of *M. equiceps*. This species is regarded by Matthew as rather close to *M. equiceps*. An animal of the same size and from the same general level as *M. equiceps* is represented by a fine skull, Amer. Mus. 7262, which is provisionally referred to this species. Provisionally referred specimens are also palates with teeth, Amer. Mus. 7282, 7292, and the upper jaw, Amer. Mus. 7266.

Miohippus longicristis Cope, 1878. *Spec. indet.*

Plate 5.1.

Anchitherium longicristis, sp. nov., Cope, E. D. "On Some of the Characters of the Miocene Fauna of Oregon," *Proc. Amer. Philos. Soc.* Vol. XVIII, 1878–1880 (sig. dated Dec. 26, 1878), p. 75, no figure. *Palæontological Bull.* No. 30, "Dec. 3, 1878."

Horizon and Locality.— (Cope) "Miocene of Oregon." Horizon John Day. Name of collector not given.

Type.— The type has apparently been misplaced, not being found (1915) in the American Museum Cope collection. (Cope) "The best specimen representing it [this species] consists of a right maxillary bone, which supports all the molars excepting the last." Measurements: (Cope) p^1–m^2 .062; p$^{1-4}$ .044; p^1 a.p. .013, tr. .014; m^2 a.p. .0125, tr. .0165. *Cotype.* Amer. Mus. 7268, a lower jaw referred by Cope to the same species.

Type figure.— Type misplaced or lost.

Characters.— (Cope) (1) Compared with *Mesohippus bairdii;* (2) infraorbital foramen above p^3; (3) no anterior basal tubercles; (4) anterior cingulum with a tubercle; (5) posterior cingulum with a large trihedral hypostyle; (6) external cingulum not strongly marked; (7) median ridges of paracone and metacone not very distinct.

(Matthew, 1913) An animal of smaller size according to Cope's measurements than any other horse in the John Day collection. Molars of cotype narrower than in other species of John Day *Miohippus*. This species will remain indeterminate until the type can be found.

Miohippus primus, sp. nov.

Plates 3.13, 4.5. Text Fig. 39.

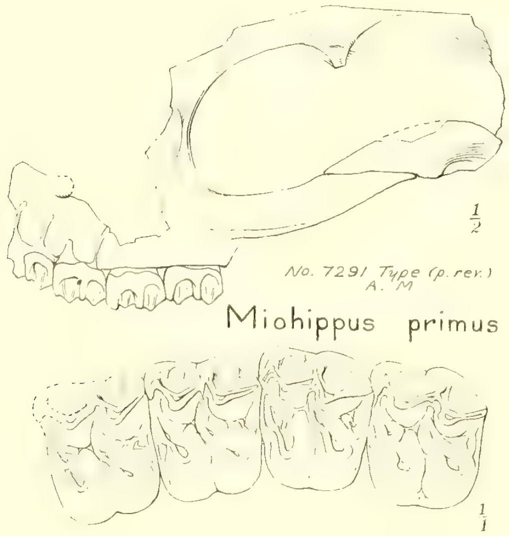

Fig. 39. Type of *Miohippus primus* Osborn, Amer. Mus. 7291, skull containing superior grinding teeth, p^3–m^2. (Upper) Lateral view of left side of skull, partly reversed in drawing. One-half natural size. (Lower) Crown view of p^3–m^2 of the left side. Natural size.

Horizon and locality.— Middle John Day of Oregon, Diceratherium zone. Type collected by J. L. Wortman, 1879.

Type.— Amer. Mus. Cope Coll. 7291. Fragmentary adult skull containing the superior grinding teeth, p^4–m^3. *Paratype.* Juvenile skull containing dp^1–m^2, Amer. Mus. 7271. Measurements: (Matthew) dp^1 a.p. .011, tr. .074; dp^2 a.p. .0193, tr. .0155; dp^3 a.p. .0166, tr. .0157; dp^4 a.p. .017, tr. .0173; m^1 a.p. .0162, tr. .019; m^2 a.p., .0151, tr. .0187.

Type figure.— Plates 3.13, 4.5, text Fig. 39 of this Memoir.

Characters.— (Matthew, 1913) (1) An animal of smaller size than the types of *M. anceps* or *M. annectens*, of larger size than the type of *M. equiceps* or *M. brachylophus*. (2) Premolars slightly broader transversely than molars, while in type of *M. anceps* they are narrower transversely than the molars; (3) vestigial internal cingulum; (4) no medivallum cusp;

(5) Protoloph interrupted by protoconule, metaloph continuous. (6) Lachrymal preorbital fossa moderate or shallow. (7) Compared with species from the Protoceras zone of South Dakota, one-ninth larger than *M. intermedius*, premolars somewhat more crested and hypsodont, and of slightly greater transverse width. (8) As compared with type of *M. gidleyi* somewhat smaller in size, protocone and hypocone evenly developed.

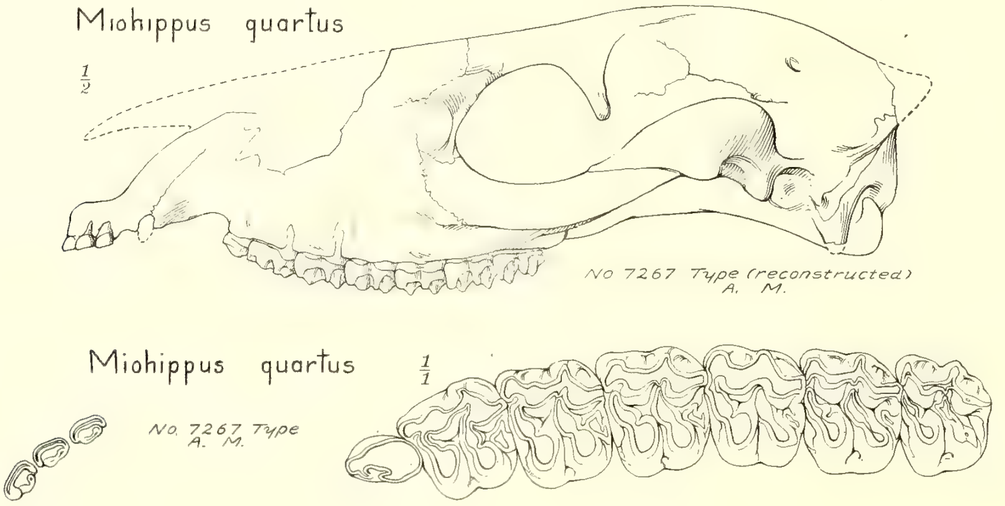

Fig. 40. *Miohippus quartus* Osborn, Amer. Mus. Cope Coll. 7267. (Upper) Skull of type, reconstructed in drawing from the right and left sides. This is the skull referred by Cope to *Anchitherium longicristis*. One-half natural size. (Lower) Superior grinding teeth of type, p^1–m^3, and the incisors of the left side. Natural size.

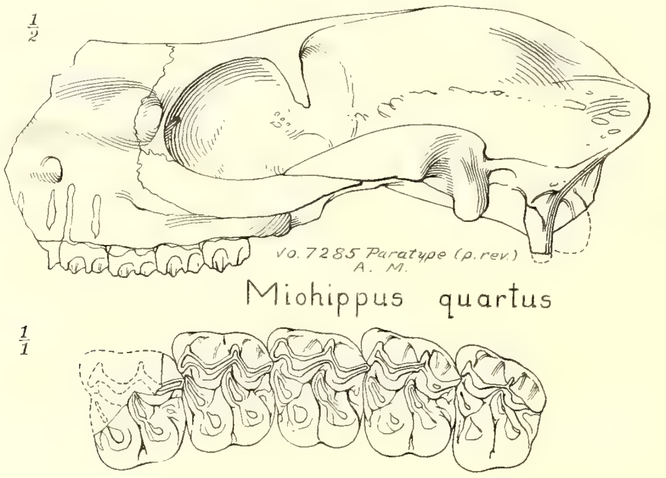

Fig. 41. *Miohippus quartus* Osborn, Amer. Mus. 7285, paratype, juvenile skull containing dp^2–m^2 of the left side. (Upper) left side of skull, one-half natural size. (Lower) Crown view of superior grinding teeth, dp^2–m^2 of the left side, dp^4, partly reversed in drawing. Natural size.

Miohippus quartus, sp. nov.

Plates 3.8, 4.6,8, 5.2. Text Figs. 40, 41.

Horizon and Locality.— Middle John Day formation, Oregon, Diceratherium zone. Type collected by J. L. Wortman, 1879.

Type.— Amer. Mus. Cope Coll. 7267. A skull and fragments of a skeleton. Specimens which were referred by Cope to *Miohippus* (*Anchitherium*) *longicristis*. *Paratype.* Amer. Mus. 7285.

Type figure.— Plates 3.8, 4.8, text Figs. 40, 41 of this Memoir.

Characters.— (Matthew, 1913) (1) About one-seventh shorter and with a muzzle relatively more slender than the type of *M. equiceps.* (2) Dentition about one-seventh smaller than that of *M. equiceps;* (3) molar teeth relatively wider transversely than in *M. equiceps* or *M. brachylophus;* (4) no internal cingulum; (5) m^3 relatively smaller than *M. equiceps* or *M. brachylophus;* (6) incisors of smaller size; (7) canines of much smaller size than in *M. equiceps*, possibly a sexual character. (8) Infraorbital border of orbit above anterior part of m^2.

Referred to this species by Matthew is the anterior portion of a skull, Amer. Mus. 7276. Of doubtful reference are lower jaws associated with fragments of the skeleton, Amer. Mus. 7274, 7293.

PROMERYCOCHŒRUS-MIOHIPPUS ZONE. 7. LOWER MIOCENE.

This zone is typified in the Upper John Day beds of Oregon and is widely distributed in western Nebraska, South Dakota, and Montana, as described above. Besides abundant *Miohippus*, it includes *Kalobatippus* and the most primitive species of *Parahippus.*

Miohippus condoni Leidy, 1870. *Spec. indet.*

Plate 3.12. Text Fig. 42.

Anchitherium condoni, Leidy, Joseph, [Collection of fossils from valley of Bridge Creek, sent by Thomas Condon] *Proc. Acad. Nat. Sci. Phila.*, Vol. XXII, 1870, p. 112, no figure. "Contributions to the Extinct Vertebrate Fauna of the Western Territories," *Report U. S. Geol. Surv. Terr., F. V. Hayden, U. S. Geologist in charge*, Vol. I, Pt. I, 1873, p. 218, Pl. ii, fig. 5.

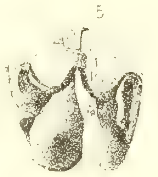

Fig. 42. Original figure of the type of *Miohippus condoni* Leidy, Acad. Nat. Sci. Phila. Coll., deciduous premolar, dp^3. Natural size. After Leidy, 1873, Pl. ii, fig. 5.

Horizon and Locality.— Upper John Day. " . . . . valley of Bridge Creek, a tributary of John Day's River, Oregon." Collected by Thomas Condon.

Type.— A broken upper molar, apparently dp^3.

Type figure.— Text Fig. 42 of this Memoir.

Characters.— The species is indeterminate from the type, which is apparently a deciduous third upper premolar. The genus is undoubtedly *Miohippus.* The size is about the same as *M. annectens* and *M. anceps.* The relative breadth of this tooth is due to its being a deciduous premolar. The hypostyle has one of the typical *Miohippus* forms of a crest parallel to the posterior cingulum.

Miohippus annectens Marsh, 1874.

Plate 3.14,15. Text Fig. 43.

Miohippus annectens, gen. et sp. nov. "Notice of New Equine Mammals from the Tertiary Formation," *Am. Jour. Sci. and Arts* (3), Vol. VII, No. 39, Mar., 1874, p. 249, no figure.

Horizon and locality.— "Miocene of Oregon," John Day formation, probably Upper John Day, Promerycochœrus zone. (Lull, R. S., letter Oct. 9, 1915) "*M. annectens,* however, is in a gray matrix which we have always considered as Upper John Day." Type collected by O. C. Marsh, November 1, 1871, from John Day River, Oregon.

Type.— Yale Mus. 11275. Type specimen not designated in original description. (Lull, R. S., letter Oct. 23, 1915): "*Miohippus annectens* is based upon three distinct specimens only one of which is marked type; this is catalogue number

11275 from John Day River, Ore., collected by O. C. Marsh, November 1st, 1871, and consists of eleven upper molar and premolar teeth. The matrix cannot be discerned as the teeth are individual teeth. The second specimen is Yale Mus. 11282, consisting of portions of both hind limbs which correspond with Marsh's type measurements; the only locality given is Oregon; the matrix was originally green but has partly weathered into gray. The third specimen [cotype], Yale Mus. 12230 consists of a skull, since partly restored by Lull; collected by Marsh November 1st, 1871; matrix seems to be gray; the reference of this last specimen to *M. annectens* is decidedly questionable. The gray matrix is associated with the Upper John Day beds." Measurements: (Marsh, 1874) p^{1-4} .061; m^{1-3} .046; m^3 a.p. .014, tr. .0195.

Type figure.— Plate 3.15, text Fig. 43 of this Memoir.

This species is the genotype of *Miohippus.*

Characters.— (Marsh, 1874, pp. 249–250) Based upon type and cotype specimens (Yale Mus. 11275, 11282, 12230). (1) Anterior margin of orbit above front of third superior molar. (2) Enamel of all teeth preserved, smooth; (3) prominent tubercle in medivallum but no internal cingulum. (4) Distinguished from *Miohippus* (*A.*) *condoni* as follows: (5) in *M.* (*A.*) *condoni* the enamel is rugose; (6) small cusp [hypostyle] behind the posterior crest is parallel with the posterior basal ridge [cingulum] and (7) the inner tubercle between the transverse crests is entirely wanting. (8) The size of the animal exceeds that of a sheep, with longer limbs.

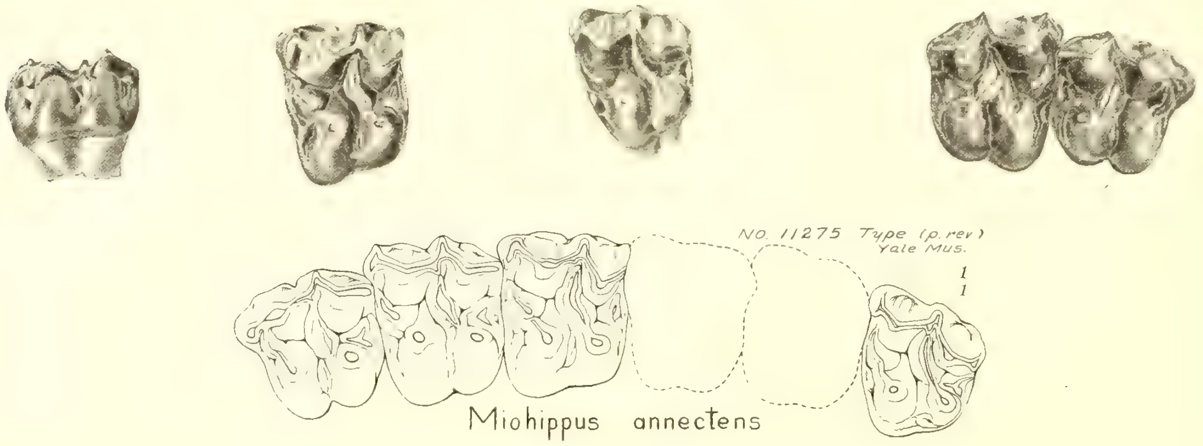

Fig. 43. *Miohippus annectens* Marsh, Yale Mus. 11275. (Right upper) Crown view of p^{2-3} of the type, of the right side. (Left upper) same view of p^4, m^3 of the left side. Drawing by S. Oka. (Lower) Composition drawing, under the direction of Osborn, of the type superior grinding teeth of the right and left sides, p^{2-3}, p^4, m^3, partly reversed in drawing. All figures natural size.

(Osborn, 1918) The characters of *M. annectens* must now be based solely upon the excellent type specimen Yale Mus. 11275 figured herewith. The association by Marsh of the other specimens as cotypes cannot be confirmed from the evidence presented by Lull (1915).

Miohippus acutidens Sinclair, 1905.

Plate 4.7. Text Fig. 44.

Mesohippus acutidens, n. sp., Sinclair, Wm. J. "New or Imperfectly Known Rodents and Ungulates from the John Day Series," *Univ. of Calif. Publ. Bull. Dept. Geol.*, Vol. 4, No. 6, July, 1905, p. 141, Pl. xviii.

Horizon and Locality.— (Sinclair) "Promerycochœrus beds (?), Upper John Day. Powell's Ranch on the Middle Fork of the John Day River about five miles above Ritter, Grant Co., Oregon." Name of collector not given.

Type.— Univ. Cal. Pal. Coll. 376. (Sinclair) "Cranium, portion of the left fore limb, and a few vertebral fragments; No. 376, Univ. of Cal. Pal. Coll." Measurements: premaxillæ to condyles 238; p^1–m^3 .085; m^{1-3} .0385; height of canine .0175; m^1 a.p. .013, tr. .016; m^2 a.p. .013, tr. .0163; m^3 a.p. .0125, tr. .016.

Type figure.— Text Fig. 44 of this Memoir.

Characters.—(Sinclair, 1905, p. 141) "Superior canines long and pointed, with acute anterior and posterior edges.

Metaloph hardly interrupted by metaconule, sharply separated by a deep notch from the ectoloph. Protoloph with well marked protoconule, united with ectoloph by a narrow sha[r]pe-edged ridge which widens in moderately worn teeth. Parastyle broadly rounded except in M^3 where it is compressed antero-posteriorly. M^3 with metaloph s[h]orter than protoloph (*i. e.*, as 8.5 mm.: 12.3 mm.), producing almost a triangular outline for the tooth crown. Mesostyle sharply defined and ribs broadly rounded and prominent. The measurements seem also to be characteristic."

Additional characters.—(Osborn, 1918) (1) Canines probably male; (2) a large hypostyle on p^1–m^3; (3) m^3 giving off a narrow spur-like cingulum which borders the hypocone posteriorly; (4) one or more small tubercles at entrance of medivallum, no other traces of internal cingulum; (5) external cingulum not continued across the bases of the styles; (6) orbit almost completely closed by a strongly developed postorbital process; (7) a well marked preorbital fossa; (8) differs from *M. brachystylus* of the Leptauchenia zone in the form of the postorbital process and in the closure of the supraorbital notch.

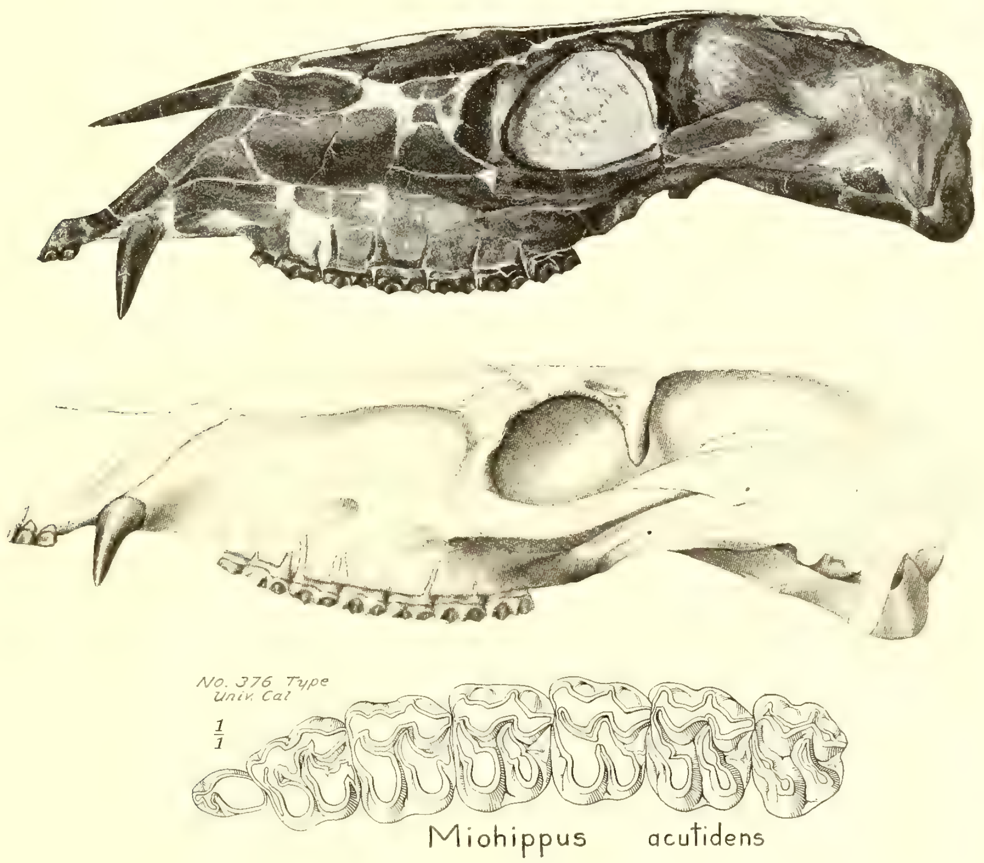

Fig. 44. *Miohippus acutidens* Sinclair, Univ. Cal. Pal. Coll. 376. (Upper) Original figure of the cranium of the type. After Sinclair, 1905, pl. 18. (Middle) Same view of type cranium drawn by B. Yoshihara under the direction of Osborn. Both figures one-half natural size. (Lower) Superior grinding teeth of the type, p^1–m^3 of the left side. Natural size.

Miohippus equinanus, sp. nov.

Plate 3.6. Text Fig. 45.

Horizon and Locality.—Lower Rosebud formation, Promerycochœrus zone, Porcupine Creek, Pine Ridge, South Dakota. Type collected by Albert Thomson, American Museum expedition of 1906.

Type.—Amer. Mus. 12912. Upper jaws containing p^1–m^3 of left side, p^{1-3} of right side. Measurements: p^1–m^3 .072; p^{1-4} .041; p^{2-4} .0363; m^{1-3} .031; p^4 a.p. .0113, tr. .0146; m^1 a.p. .0114, tr. .0145.

Referred specimens from the same horizon: upper jaws, Amer. Mus. 12914, 12917c, 12917d; lower jaws with teeth, Amer. Mus. 12913, 12916, 12917e, 12919, 12920.

Type figure.— Plate 3.6, text Fig. 45 of this Memoir.

Characters.— (Matthew, 1913, Osborn, 1918) (1) The type is an animal of slightly smaller size than the type of *Mesohippus bairdii*, more progressive in dentition and in foot construction. (2) Teeth slightly more hypsodont than in *M. bairdii;* (3) p$^{2-4}$ occupy more space (.036) than m$^{1-3}$ (.031); (4) m^{3} considerably reduced; (5) parastyle of p^{2} prominent, elongating; (6) metaloph nearly uniting with ectolophs of molars, also uniting in an early stage in the premolars; (7) hypostyle relatively large on premolars and molars; (8) lower teeth in referred specimens with metaconid and metastylid cusps relatively large and distinct; (9) metalophid united with metastylid in an early stage of wear.

In the paratype referred lower jaw, Amer. Mus. 12920, with various parts of hind foot, we observe: (10) median metatarsal larger than in *M. bairdii;* (11) shafts of lateral metatarsals relatively smaller; (12) Mts. III with a small, oblique articulation of cuboid. Also in the juvenile upper jaws, Amer. Mus. 12917c, 12917d, (14) the milk premolars agree in crown pattern with the permanent premolars but the transverse width is less, and (15) both in the milk and permanent premolars metalophs unite with ectolophs at an early stage of wear.

This species of dwarf horse, which may be known as *Miohippus equinanus*, should be compared with Cope's dwarf horse from the John Day, *M. longicristis*, the type of which is unfortunately lost. The referred lower jaws are much smaller than the cotype of *M. longicristis*. Although the type and all the referred specimens are of smaller size than the type of *Mesohippus bairdii* from the Oreodon zone of the Middle Oligocene, these animals are more progressive in dentition and in foot structure; in some respects they are so progressive as to present an approximation toward the dental type of *Parahippus* (Matthew, 1915).

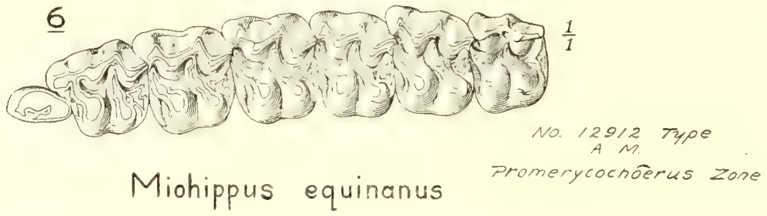

Fig. 45. *Miohippus equinanus* Osborn, Amer. Mus. 12912, superior molar-premolar series of the type, p^{1}–m^{3} of the left side. Natural size.

Miohippus gemmarosæ, sp. nov.

Plates 3.7, 4.1,2,3,4,9. Text Figs. 46, 47.

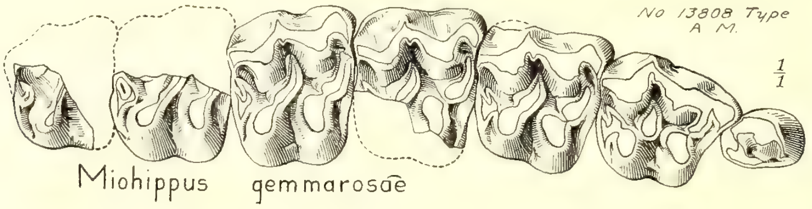

Fig. 46. Crown view of the superior grinding teeth of the type of *Miohippus gemmarosæ* Osborn, Amer. Mus. 13808, p^{1}–m^{3} of the right side. Natural size.

Horizon and locality.— From the Lower Rosebud formation, Promerycochœrus zone, Bear-in-Lodge Creek, Pine Ridge, South Dakota. Type collected by Paul Miller, American Museum Expedition of 1907.

Type.— Amer. Mus. 13808. Upper teeth and skull fragments. Measurements: p$^{1-4}$ .062; m^{1} a.p. .016, tr. .0214; m^{2} .016. Referred specimens, or *paratypes,* all from Lower Rosebud, Pine Ridge, South Dakota, upper and lower jaw

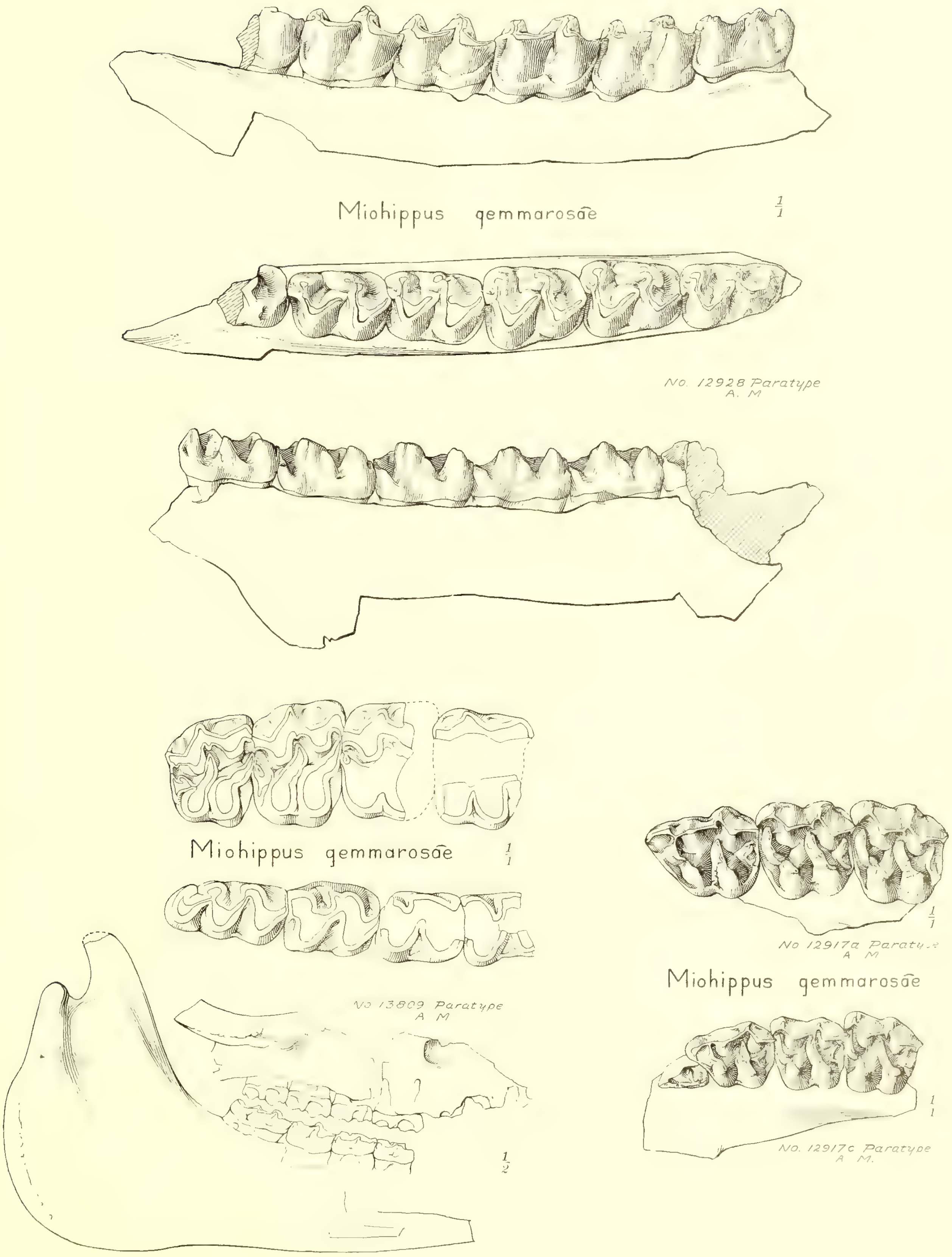

Fig. 47. PARATYPES OF *MIOHIPPUS GEMMAROSÆ* OSBORN.

(Upper) Am. Mus. 12928, fragment of right lower jaw containing p_2–m_3. External, crown, and internal views. Natural size. (Lower left) Am. Mus. 13809, portions of skull and jaw from the right side; crown view of upper jaw with p^4, m^3 of the right side, and lower jaw with p_4–m_3 of the right side. Natural size. (Right upper) Am. Mus. 12917a, crown view of deciduous premolars, dp^{2-4}; (right lower) Am. Mus. 12917c, crown view of deciduous premolars.

fragments, Amer. Mus. 13809, from Porcupine Creek; fragment of lower jaw, p_2–m_3, Amer. Mus. 12928, from Eagle Nest Butte; upper milk molars, unworn, Amer. Mus. 12917a, from Porcupine Creek, Amer. Mus. 12917c.

Type figure.— Plates 3.7, 4.9, text Fig. 46 of this Memoir.

Characters.— (Matthew, 1913) (1) Same size as *Miohippus annectens* and *M. anceps.* (2) Premaxillary alveoli indicate incisors and canine of exceptionally large size; (3) p^2 of less transverse but greater antero-posterior diameter than *M. anceps* and *M. annectens;* (4) p^2 relatively narrow and elongate, p^1 relatively large; (5) metaloph not united with ectoloph; (6) premolars with somewhat larger parastyle, especially on p^2, than in *M. annectens;* (7) no internal cingula, no intermediate basal cusps; (8) hypostyle better developed on true molars.

In a referred juvenile specimen, Amer. Mus. 12917a, the deciduous premolars resemble the permanent premolars in the crown pattern and transverse diameter. Metaloph separated from ectoloph. (1) In a referred Amer. Mus. lower jaw, metastylid quite distinct, p_2–m_3, although less well separated than in *Parahippus;* (2) metalophid not united with metastylid until tooth is well worn.

The name *gemmarosæ* is founded on the Latin for the word Rosebud, the name which has been applied by Matthew to the beds from which this specimen was secured.

GENUS **KALOBATIPPUS** OSBORN, 1915.

Genotype.— *Anchitherium præstans* Cope 1879; *Kalobatippus* Osborn, see Cope-Matthew, 1915, pl. CVIII.

The separation of this genus was first suggested to the author by W. D. Matthew. The type (Amer. Mus. 7269) is from the higher levels of the Upper John Day. The principal distinction is the great elongation of the central digits of the manus and pes, to which the name *Kalobatippus* (= stilt-walking horse) refers.

The principal characters are as follows:

1. Metaloph united to ectoloph (as in *Anchitherium*, *Hypohippus*, *Archæohippus*).
2. Anterior margin of orbit above posterior end of m^3, as in *Archæohippus*.
3. Size exceeding that of any of the known species of *Miohippus* and *Archæohippus*.
4. Teeth more brachyodont than in *Anchitherium*.
5. No internal cingulum.
6. Protolophs of molars and metalophs of p^{3-4} incomplete.
7. Last upper molar, and heel of m_3 unreduced.
8. No crochet.
9. Incisor row broadly rounded.
10. Lachrymal fossa shallow.
11. Malar fossa broad and not very deep.
12. Hind foot with elongate metatarsals and short phalanges; foot longer and more slender than in *Anchitherium* or *Hypohippus*.
13. Lateral digits not more reduced than in *Anchitherium*.
14. Mts. III-cuboid facet strong.
15. Mts. III with strong meso-ectocuneiform facet, as in *Anchitherium* and *Hypohippus*.

I. TYPE DESCRIPTIONS OF THE SPECIES OF KALOBATIPPUS IN CHRONOLOGIC ORDER.

Date	Original name and author	Present reference	Locality	Life zone
1879	*Anchitherium præstans* Cope	*Kalobatippus præstans*	John Day Series, Oregon	Promerycochœrus zone
1892	*Pliohippus gracilis* Marsh	? " *gracilis*	" " " "	?Promerycochœrus-Miohippus zone
1918	*Kalobatippus agatensis* Osborn	" *agatensis*	Agate, western Nebraska	Promerycochœrus-Miohippus zone

II. TYPES AS RECORDED OR INFERRED IN 1917 IN GEOLOGIC SUCCESSION.

Date	Species, Present reference	Life zone	Formation, Beds	Locality	Age
1918	*Kalobatippus agatensis*	Promerycochœrus-Miohippus zone	Lower Harrison formation	Agate, western Nebraska	Lower Miocene
1892	?*Kalobatippus gracilis*	?Promerycochœrus-Miohippus zone	?Upper John Day	John Day Series, Oregon	" "
1879	*Kalobatippus præstans*	Promerycochœrus-Miohippus zone	Upper John Day	" " " "	" "

The shallow fossæ, posterior position of orbits, unreduced $m\frac{3}{3}$, brachyodont grinders, and especially the long, slender limbs and feet, with short phalanges, distinguish this animal from *Anchitherium*. The unreduced lateral digits, brachyodont teeth with no crochet, posterior position of orbit, primitive odontoid process, and especially the facet of the mesocuneiform on Mts. III distinguish it from *Parahippus*. These characters are displayed in Plate 5.6,7,10,12, Plate 6.3, Plate 39.17,20, Plate 40, Plate 51.7,10,14.

Kalobatippus præstans Cope 1879.

Plates 5.6,10,12, 6.3, 51.10,14. Text Figs. 48, 51.

Anchitherium præstans, Cope, E. D. "A New Anchitherium," *Amer. Naturalist*, Vol. XIII, No. 7, July, 1879, pp. 462–463, no figure. "The Perissodactyla," *Amer. Naturalist*, Vol. XXI, No. 12, Dec. 1887, p. 1069, fig. 36.

Horizon and Locality.— Summit of Upper John Day, Promerycochœrus zone. Name of collector not known.

Type.— Amer. Mus. 7269. Skull, jaws, tibia, and pes. Measurements: (Cope) "Length of molar series .118m.; of true molars, .050; length anterior to molars, .061; width between last molars, .040; diameters of crown of second true molar, fore and aft, .017, transverse, .022; length of tibia, .285; of metacarpal, .221."

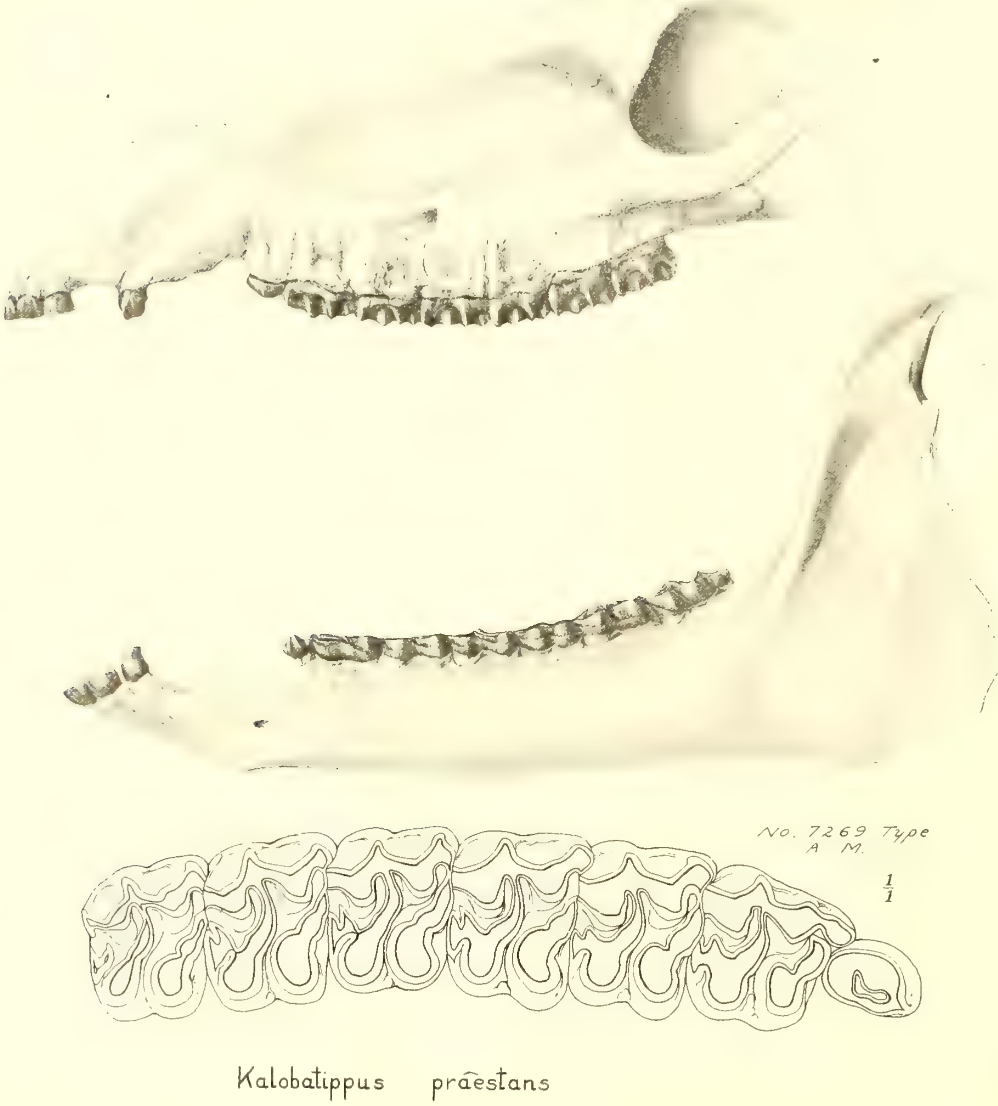

Fig. 48. *Kalobatippus præstans* Cope, Amer. Mus. 7269, skull and jaws of type, and crown view of the superior grinding series of the right side. Skull one-half natural size, teeth natural size. Skull drawings by B. Yoshihara.

Type figure.— Cope 1887, fig. 36, not reproduced here.

Characters.— (Cope, 1879, pp. 462–463) "It is the largest species [of *Anchitherium*] yet found in America, and exhibits the typical characters of the genus. On the posterior border of the superior molars there is a trihedral tubercle [hypostyle] in front of the elevated posterior cingulum, but the anterior cingulum does not rise into a tubercle, nor is there an accessory tubercle near it. The internal lobes of the crown are closely connected with the median lobes. External ribs and cingulum prominent; enamel smooth. The side of the face is concave, and there is a lachrymal fossa. The anterior border of the orbit marks the middle of the last molar tooth."

Kalobatippus gracilis Marsh 1892.

Text Figs. 49, 51.

Pliohippus gracilis, Marsh, O. C. "Recent Polydactyle Horses," *Amer. Jour. Sci. and Arts*, (3), Vol. XLIII, No. 256, 1892, p. 347, no figure.

Horizon and locality.— (Marsh)" . . . . the Pliocene of Oregon." Probably Upper John Day. Name of collector not given [William W. Day].

Type.— Yale Mus. 11301 (Marsh) "A small species of *Pliohippus* from the Pliocene of Oregon . . . . An incomplete hind foot in the Yale Museum . . . . The species is new and may be called *Pliohippus gracilis*." (Lull, 1916) "The type of Pliohippus gracilis, Yale Mus. consists of a right foot and a few other bones, marked 'Pliocene (Palo Duro) from Dayville, Ore. Collected by William W. Day.'"

Type figure.— Text Figs. 49, 51 of this Memoir.

Characters.— (Marsh) " . . . . shows the second metatarsal as a splint bone, the third very long and slender, and the fourth so well developed that it probably supported phalanges. This may also be a case of reversion."

Gidley, 1907, p. 911, observes: "This species was not well defined by Marsh, nor does the type show any especially distinctive features . . . . The species is therefore indefinitely known at present."

The type hind foot of *? Kalobatippus* (*Pliohippus*) *gracilis* is of a decidedly primitive type, much more primitive than *Pliohippus* or even *Parahippus;* it may rather be compared with the type of *Kalobatippus præstans* of the Upper John Day, in fact, the matrix and the color of the type specimen resemble those of Upper John Day fossils. In conformity with the *K. præstans* type the navicular is relatively deep (a primitive character); the median metatarsal is elongate, and laterally compressed; the lateral digits are wide, flat, and thin; the ectocuneiform, mesocuneiform, and entocuneiform are coössified; there is a slight overlapping of the entocuneiform on the head of Mts. III; the distal keel of Mts. III is very obscure on the front face being hardly visible.

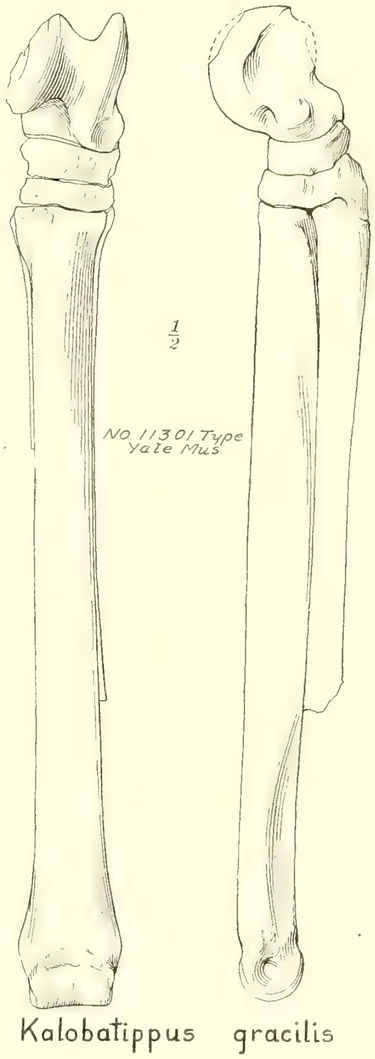

Fig. 49. Type of *? Kalobatippus gracilis* Marsh, Yale Mus. 11301. One-half natural size.

Kalobatippus agatensis sp. nov.

Plates 5.7, 39.17,20, 40, 51.1,4. Text Fig. 50.

Horizon and locality.— Harrison formation, lower horizon, Promerycochœrus zone, upper Niobrara River, near Agate, western Nebraska.

Type.— Amer. Mus. 14211. A lower jaw associated with vertebræ, limb bones, and fore and hind feet. Measurements: p_1–m_3 .128; inferred length of p^1–m^3 .118.

Type figure.— Plates 5.7, 39.17, 20, 40, 51.1,4, text Fig. 50 of this Memoir.

Characters.— (Matthew, 1913) (1) Teeth with higher crowns than in *Kalobatippus præstans;* (2) premolars relatively 10% broader; (3) anterior lobe of p_2 relatively narrower, with atrophied antero-external cingulum; (4) entoconulid of m_3

with distinct cusp; (5) external cingula vestigial or absent; (6) postcanine diastema one-third shorter than *K. præstans;* (7) symphysis shorter, more massive, incisors more robust. (8) Magnum–Mtc. II, articulation narrower; (9) feet about one-eighth larger in all dimensions. The type and cotype include lower jaws of two individuals in slightly different degrees of wear which unquestionably pertain to the same species. With one of the jaws is associated a considerable part of the skeleton, all of one individual, including the cervicals except C 2–3, D 2–9, also three posterior dorsals, L 1, and part of S 1, a few ribs, scapulæ, pelvis, humerus, most of both radii and ulnæ, magnum, Mtc. II, III of both sides, 1st median phalange of fore foot, distal part of femur, one hind foot nearly complete, and parts of the other.

(Matthew, 1913) While the affinity to *Anchitherium* and *Hypohippus* is evident throughout, this animal equals *Hipparion* in the length and slenderness of the hind limb and exceeds it in the length of the fore limb. The phalanges are anchitheriine, as well as all the details of the upper limbs, feet, and vertebræ, and the proportions of the head and neck.

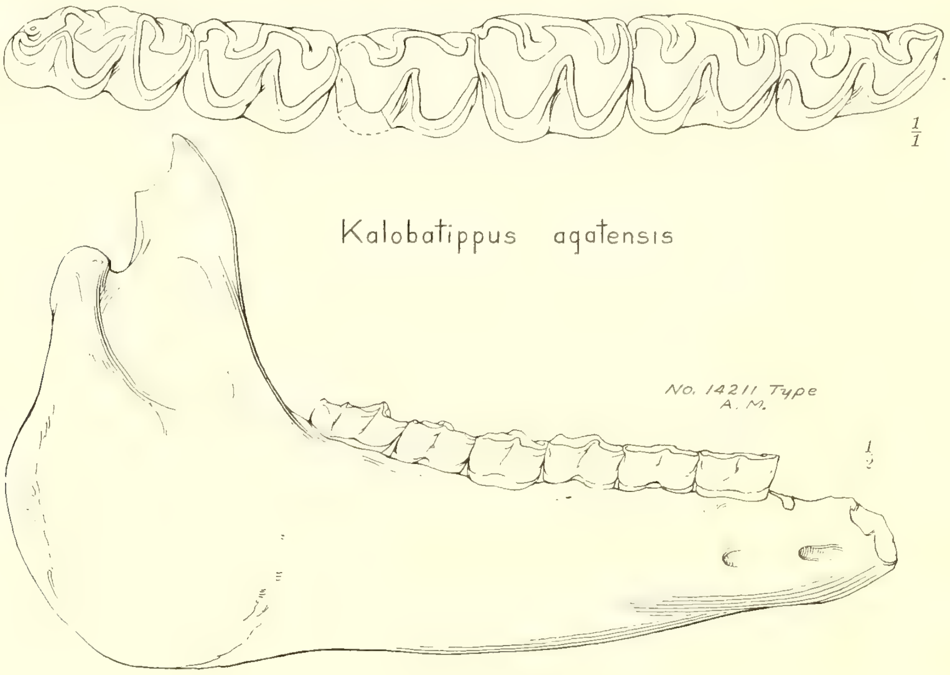

Fig. 50. *Kalobatippus agatensis* Osborn, Amer. Mus. 14211. (Upper) Crown view of inferior grinding teeth of the type, p_2–m_3 of the right side. Natural size. (Lower) Right lower jaw of the type, containing p_2–m_3. One-half natural size.

The proximal phalanges resemble those of *H. osborni* and are much shorter and wider than those in the Protohippinæ. Other proportions are distinctive, namely: (1) the neck is one-fourth longer than in *Hipparion whitneyi;* (2) the animal is microcephalic, the skull being remarkably small in proportion to the skeleton.

	Kalobatippus agatensis Type, Am. Mus. 14211	*Hypohippus osborni* Type, Am. Mus. 9407	*Hipparion whitneyi* Type, Am. Mus. 9815
P^1–m^3	.118e	.152	.151
Metacarpal III, length	.225	.201	.212
“ “ width, distal end	.027	.032	.026.5
Phalange III, 1, length	.041	.038	.045.5
“ “ width, distal end	.025.5	.027	.020
Metatarsal III, length	.027	.032	.024.5
Phalange III, 1, length	.039	.044	.044
“ “ least width of shaft	.022.5	.027	.020
“ III, 2, length	.030.5	.035	.027

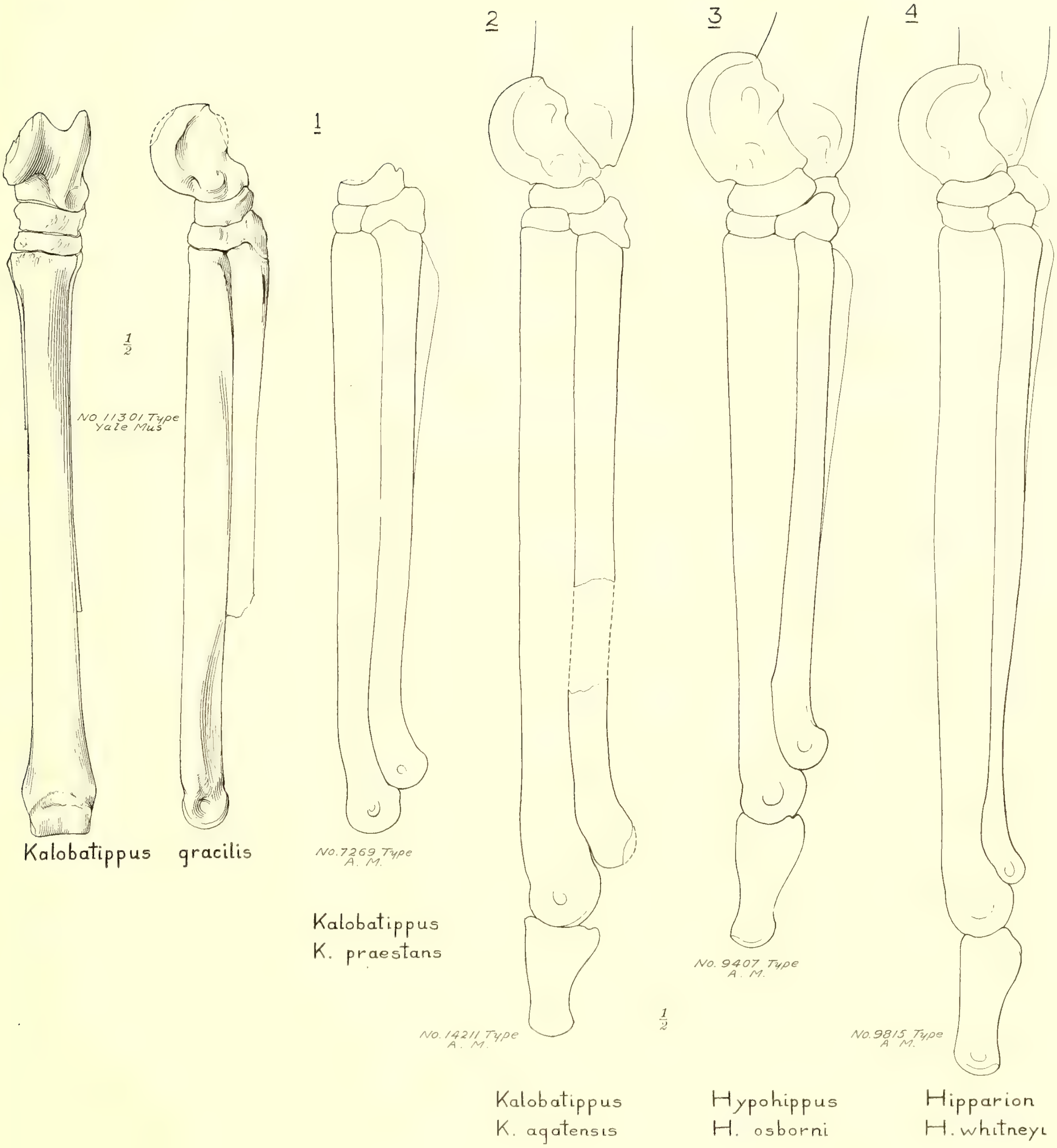

Fig. 51. Hind feet of *Kalobatippus.*

Kalobatippus præstans Cope, Amer. Mus. 7269, *K. gracilis* Marsh, Yale Mus. 11301, and *K. agatensis* Osborn, Amer. Mus. 14211, from the type specimens. Hind limbs of *Hypohippus* and *Hipparion* types inserted for comparison. All figures one-half natural size.

GENUS **PARAHIPPUS** LEIDY, 1858.

Proc. Acad. Nat. Sci. Phila., 1858, p. 26.

Genotype.— Parahippus (*Anchitherium*) *cognatus* Leidy, from the Nebraska formation, Procamelus-Hipparion zone, of the Niobrara River, Nebraska.

Synonyms.— Desmatippus Scott, genotype, *Desmatippus crenidens*, *Amer. Naturalist*, Vol. XXVII, July, 1893, p. 661, from the Deep River formation, Deep River valley, Middle Miocene, Montana. *Altippus* Douglas, *genotype*, *Parahippus* (*Altippus*) *taxus*, from the Upper Oligocene or Lower Miocene of Woodin, Divide Creek, Silver Bow County, Montana.

Eighteen species now referred to the genus *Parahippus*, described between 1858 and 1918, are included within this stage of evolution, which is closely connected with that of *Miohippus* below and of *Merychippus* above. The geologic distribution is an extremely long one, extending from the diminutive *Parahippus pristinus* and the *P. tyleri* of the Promerycochœrus zone of the Lower Rosebud and Lower Harrison of South Dakota and western Nebraska, through the Merycochœrus zone of the Upper Harrison, in which *Parahippus* is very abundant, through the entire Ticholeptus-Merychippus zone of the Middle Miocene, and up into the Procamelus-Hipparion zone of the Lower Pliocene where the genotype *Parahippus cognatus* is said to occur, recorded with remains of such progressive horses as *Protohippus*, *Pliohippus*, and *Hipparion*. The explanation of this survival is that *Parahippus*, like *Hypohippus*, had a local adaptive radiation and distribution of its own, favoring a browsing country adapted to its relatively short-crowned grinding teeth.

1. Grinding teeth structurally intermediate between *Miohippus* and *Merychippus* stages.
2. P$^{2-4}$ invariably of greater length than m$^{1-3}$.
3. P$^{3-4}$ invariably broader than m^{1}.
4. Deciduous and permanent grinding teeth brachyodont to subhypsodont.
5. Cement thin or wanting, late in development, progressively heavy (*P. avus*). Enamel surface rugose.
6. Protocone and hypocone relatively large as compared with the simple lophoid protoconule and metaconule.
7. Metaloph with crochet progressively increasing in size (*P. cognatus*, *P texanus*).
8. Anterior enamel wall of metaloph ptychoid or crenulate in certain species (*P. crenidens*, *P. cognatus*).
9. Pre- and postfossettes (cement lakes) tending to close through development of crochet and of hypostyle.
10. Hypostyle prominent, subtriangular.
11. Metaconid-metastylid column and hypoconid-hypostylid column of inferior grinders broadening.
12. Lachrymal fossa vertically broad, shallow, and separate; malar fossa not present.
13. Facial region always greatly exceeding cranial region.
14. Orbit closed posteriorly.
15. Digits of manus and pes anisotridactyl, *i. e.* lateral digits considerably reduced.

Matthew (1913) has suggested the division of *Parahippus* into three groups, as follows:

Group I	Group II	Group III
Parahippus cognatus Upper Miocene	*Parahippus pawniensis* Middle Miocene	*Parahippus coloradensis* Middle Miocene
“ *avus* Middle “	“ *crenidens* “ “	“ “ *præcurrens*, Lower Miocene
“ *nebrascensis* Lower “	“ *pristinus* Lower “	
“ *texanus* “ “	“ *pawniensis atavus* “ “	
“ *tyleri* “ “		
Distinguished by relatively short-crowned teeth, shallow fossæ, heavily proportioned limbs, feet moderately elongate, ungual phalanges short and small.	Teeth short-crowned, simple, crochet simple, incipient accessory foldings of metaloph, size small, fossæ rather deep, limbs slender, moderately long, phalanges short, ungual phalanges long and narrow.	Teeth long-crowned, crochet well developed, with accessory minor crests, external ribs prominent, feet long, slender, lateral digits greatly reduced; phalanges of moderate length.

Thus according to Matthew's observations of 1913 *Parahippus* divides into at least three distinct parallel phyla distinguished by the characters of the grinding teeth and of the preorbital fossæ, and by the stout or relatively slender limbs.

I. TYPE DESCRIPTIONS OF THE SPECIES OF PARAHIPPUS IN CHRONOLOGIC ORDER.

Date	Original name and author	Present reference	Locality	Life zone
1858	*Anchitherium (Parahippus) cognatus* Leidy	*Parahippus cognatus*	Ft. Niobrara, Nebr.	Procamelus-Hipparion zone
1868	*Anchippus texanus* Leidy	“ *texanus*	Independence, Washington County, Texas	Zone undetermined
1873.1	*Anchitherium ?australe* Leidy	“ *australis*	“ “ “ “	“ “
1873.2	“ *agreste* Leidy	“ *agrestis*	Red Rock Creek, Jefferson Fork, Mont.	“ “
1874.1	*Protohippus avus* Marsh	“ *avus*	Cottonwood Creek, Oregon	Merycochœrus-Parahippus zone, ?Merychippus zone
1874.2	*Anchippus brevidens* Marsh	“ *brevidens*	“ “ “	Ticholeptus-Merychippus zone
1893	*Desmatippus crenidens* Scott	“ *crenidens*	Deep River, Mont.	“ “ “
1899	*Anchitherium minimus* Douglass ?	“ *minimus*	Lower Madison Valley, Mont.	Zone undetermined
1907.1	*Parahippus pawniensis* Gidley	“ *pawniensis*	Logan Co., northeastern Col.	Ticholeptus-Merychippus zone
1907.2	“ *coloradensis* Gidley	“ *coloradensis*	“ “ “ “	“ “ “
1907.3	“ *nebrascensis* Peterson	“ *nebrascensis*	Sioux Co., Nebr.	Merycochœrus-Parahippus zone
1908.1	*Altippus taxus* Douglass	*Parahippus taxus*	Divide Creek, Silver Bow Co.	Entoptychus-Promerycochœrus zone
1908.2	*Parahippus tyleri* Loomis	“ *tyleri*	Lower Harrison, Agate, Sioux Co., Nebr.	Promerycochœrus-Miohippus zone
1916	“ *leonensis* Sellards	“ *leonensis*	near Tallahassee, Fla.	?
1918.1	“ *pristinus* Osborn	“ *pristinus*	Porcupine Creek, So. Dak.	Promerycochœrus-Miohippus zone
1918.2	“ *coloradensis præcurrens* Osborn	“ *coloradensis præcurrens*	“ “ “ “	Merycochœrus-Parahippus zone
1918.3	“ *pawniensis atavus* Osborn	“ *pawniensis atavus*	Agate, Sioux Co., Nebr.	“ “ “
1918.4	“ *nebrascensis primus* Osborn	“ *nebrascensis primus*	“ “ “ “	“ “ “

II. TYPES AS RECORDED OR INFERRED IN 1917 IN GEOLOGIC SUCCESSION

Date	Species, Present reference	Life zone	Formation, Beds	Locality	Age
1916	*Parahippus leonensis* Sellards	?	Alum Bluff formation	near Tallahassee, Fla.	Miocene
1858	“ *cognatus* Leidy	?Procamelus-Hipparion zone	Niobrara River, Ft. Niobrara, Nebr.	Ft. Niobrara, Nebr.	Upper Miocene–Lower Pliocene
1899 ?	“ *minimus* Douglass	Zone undetermined		Lower Madison Valley, Mont.	?Lower Pliocene
1907.2	“ *coloradensis* Gidley	Ticholeptus-Merychippus zone	Pawnee Creek formation	Logan Co., northeastern Colorado	Upper Miocene
1907.1	“ *pawniensis* Gidley	“ “ “	“ “ “	“ “ “ “	“ “
1893	“ *crenidens* Scott	“ “ “	Deep River “	Deep River, Mont.	“ “
1874.2	“ *brevidens* Marsh	“ “ “	?Mascall formation	Cottonwood Creek, Ore.	“ “
1874.1	“ *avus* Marsh	?Merycochœrus-Parahippus zone ?Merychippus zone	?Upper John Day ? Mascall	“ “ “	Lower or Middle Miocene
1873.2	“ *agrestis* Leidy	Zone undetermined	Red Rock Creek, Jefferson Fork, Missouri River, Mont.	Red Rock Creek, Jefferson Fork, Mont.	?Miocene
1908.2	“ *taxus* Douglass	Entoptychus-Promerycochœrus zone	Divide Creek, Mont.	Divide Creek, Silver Bow Co., Mont.	Miocene
1873.1	“ *australis* Leidy	?Procamelus-Protohippus zone	?	Independence, Wash. Co., Texas	?Upper Miocene
1868	“ *texanus* Leidy	Zone undetermined	?	“ “ “	?Middle Miocene (Upper levels)
1918.2	“ *coloradensis præcurrens* Osborn	Merycochœrus-Parahippus zone	Upper Rosebud formation	Porcupine Creek, So. Dak.	Lower Miocene
1918.4	“ *nebrascensis primus* Osborn	“ “ “	Upper Harrison “	Agate, Sioux Co., Nebr.	“ “
1918.3	“ *pawniensis atavus* Osborn	“ “ “	“ “ “	“ “ “ “	“ “
1907.3	“ *nebrascensis* Peterson	“ “ “	“ “ “	Sioux Co., Nebr.	“ “
1908.3	“ *tyleri* Loomis	Promerycochœrus-Parahippus zone	Lower Harrison “ (upper levels)	Agate, Sioux Co., Nebr.	“ “
1918.1	“ *pristinus* Osborn	“ “ “	Lower Rosebud	Porcupine Creek, So. Dak.	“ “

Parahippus pristinus sp. nov.

Plate 6.5, 9.7, 25.1, 36.1. Text Fig. 52.

Horizon and locality.— Lower Rosebud formation of Porcupine Creek, Pine Ridge, South Dakota. Type collected by Amer. Mus. Expedition of 1906.

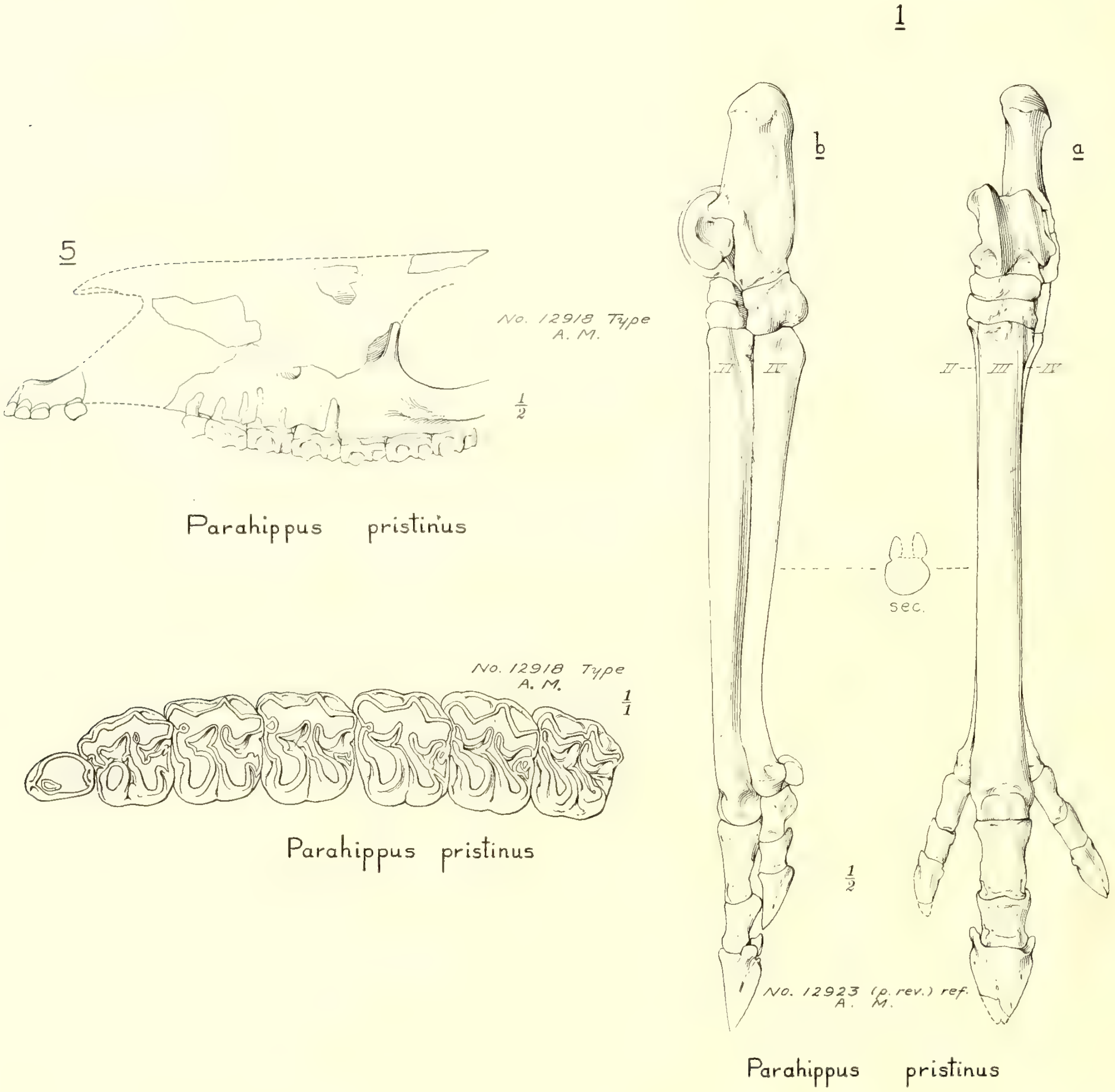

Fig. 52. *Parahippus pristinus* Osborn. (Left figures) Amer. Mus. 12918, type. Side view of skull, one-half natural size; crown view of left superior grinding series, natural size. (Right) Hind foot of a referred specimen, Am. Mus. 12923, (a) front and (b) external views with cross section of metatarsals. One-half natural size; partly reversed in drawing.

Type.— Amer. Mus. 12918. Palate and symphysis mandibuli including all teeth except incisors of left side and the right canine.

Type figure.— Plate 6.5, 9.7, text Fig. 52 of this Memoir.

Characters.— (Matthew, 1913) (1) Size not exceeding *Miohippus intermedius.* (2) Grinding teeth somewhat more hypsodont; (3) metalophs united with ectolophs on all grinding teeth; (4) rudimentary or small pli hypostyle except on p^2; (5) premolars scarcely larger than molars, their transverse diameter not so great. (6) Preorbital (lachrymal) fossa moderately deep; (7) anterior border of orbit above anterior end of m^2. (8) Metatarsals long and slender with lateral digits moderately reduced; (9) first phalanges rather short; (10) ungual phalanges narrow; (11) a small, deep fossette on Mts. III for cuboid.

Referred Specimens.— The characters of the type are confirmed by the referred specimens American Museum 12915, 12917b, 12921, 12922, 12923, all from the Lower Rosebud. The type represents an animal of smaller size and more brachyodont than any other known form of *Parahippus*, the size and characters of the teeth being very suggestive of *Archæohippus*, but the orbit is further forward and the lachrymo-malar fossa not very deep. The presence of a crochet on all the superior grinders except p^2 relates this animal to *Parahippus*.

Parahippus tyleri Loomis 1908.

Plate 9.6,8, 39.10,12. Text Figs. 53, 54, 56.

Parahippus tyleri sp. nov., Loomis, F. B. "A New Horse from the Lower Miocene," *Amer. Jour. Sci. and Arts*, (4), Vol. XXVI, No. 152, Aug., 1908, pp. 163–164, fig. 1.

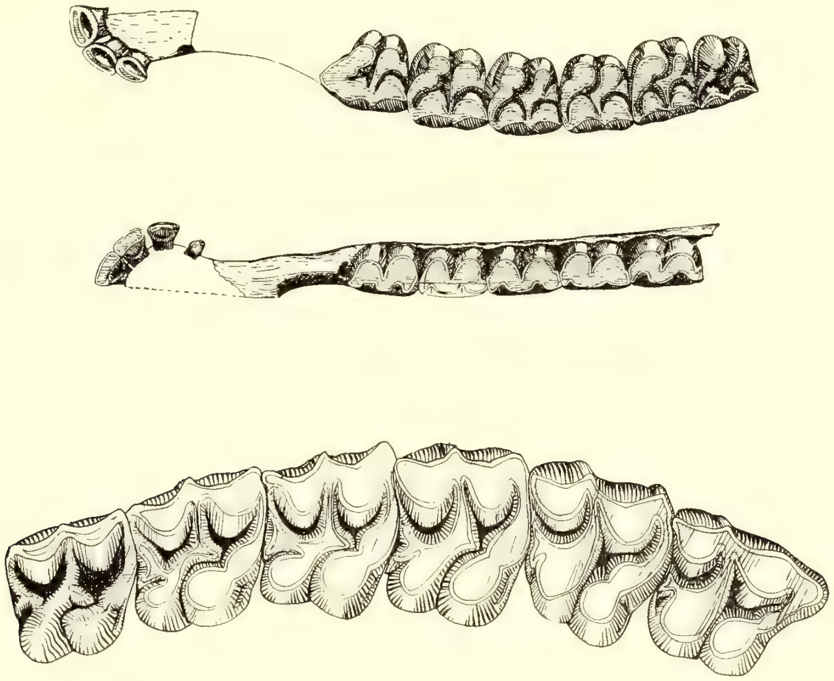

Fig. 53. Type of *Parahippus tyleri* Loomis, Amherst College Coll. 1079. (Upper) Original figures of type. One-half natural size. After Loomis, 1908, fig. 1, p. 163. (Lower) Crown view of p^2–m^3, drawn by F. B. Loomis. Natural size.

Horizon and Locality.— Upper part of the Lower Harrison beds, eight miles northeast of Agate, Sioux Co., Nebraska, Promerycochœrus zone, Upper Oligocene. Type collected by Harold Cook, 1907.

Type.— Amherst College Coll. 1079. (Loomis) "A skull numbered 1079 in the Amherst College Museum which while lacking the brain case preserves all the dentition except the upper canine and the first premolar of the upper and lower jaw." Measurements: length of m$^{1-3}$ .055; p$_{2-4}$ .056; m$_{1-3}$ .059.

Type figure.— Text Fig. 53 of this Memoir.

Characters.— (Loomis) (1) About one-fourth smaller than *P. nebrascencis.* (2) Facial portion of skull moderately

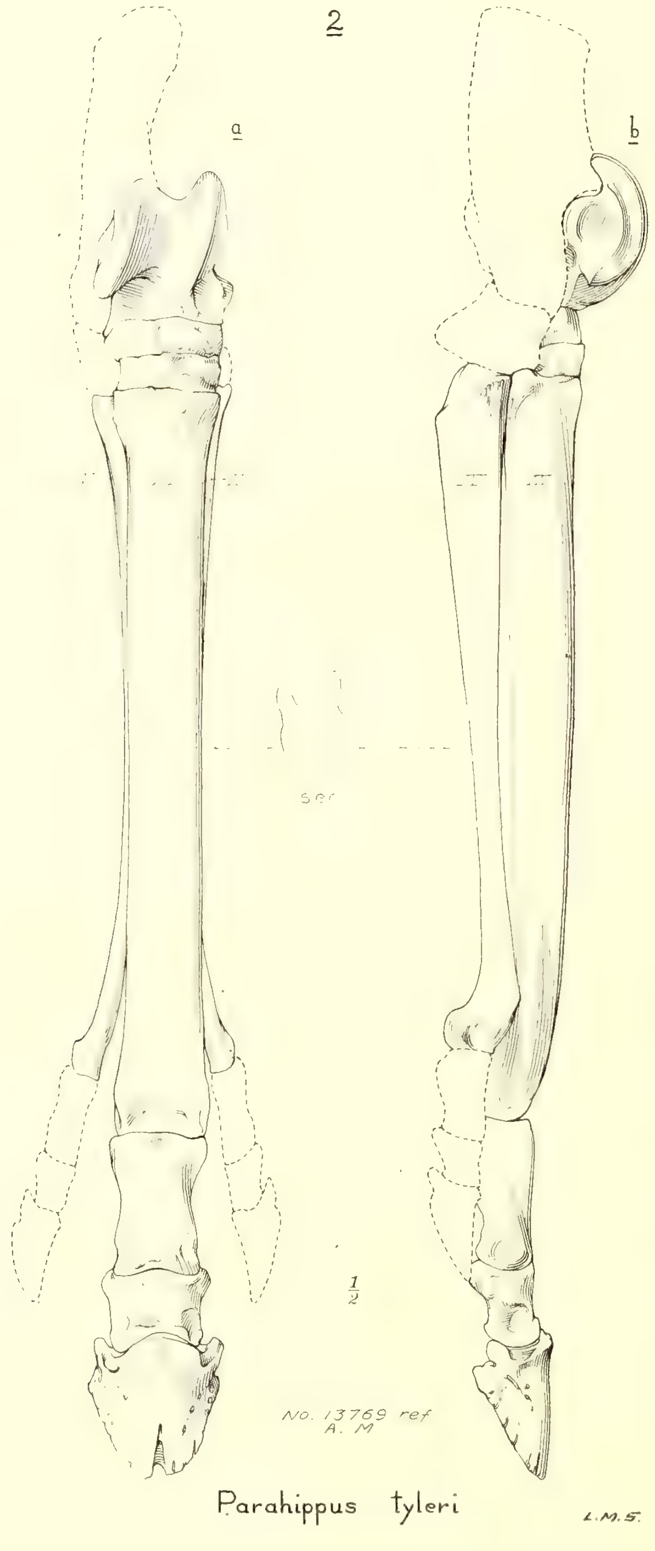

Fig. 54. *Parahippus tyleri* Loomis, Amer. Mus. 13769, right pes of referred specimen. (a) Front and (b) external views, with cross section of metatarsals. One-half natural size.

high and narrow. (3) In upper incisors a deep pit entirely surrounded by raised internal cingulum; (4) canine alveolus small [possibly a female]; (5) parastyle and mesostyle less prominent than in *P. nebrascencis;* (6) vestigial cingulum on protoloph; (7) protocone and protoconules separated by a narrow constriction; (8) metalophs of p^4–m^3 exhibit small crochet; (9) metalophs not uniting, thus pli crochet not entirely isolated; (10) hypostyle strong, notched posteriorly; (11) pit in lower incisors resembling a groove; (12) p_1 diminutive, p_2–m_3 with well marked external cingulum terminating in a diminutive hypoconulid; (13) heel of m_3 moderate in size; (14) no indication of cement.

Referred specimens.— (Matthew, 1913) From the Lower Harrison a crushed skull, jaws, and greater part of skeleton, Amer. Mus. 13769, and upper jaws, Amer. Mus. 13767, are referred to this species. These specimens agree with Loomis's type in the following characters: (1) teeth moderately brachyodont; (2) crochet absent on p^{2-3}, small and simple on other grinding teeth; (3) premolars relatively small, scarcely exceeding m^{1-3} in length and distinctly less in width; (4) small canines in type, a female character, large canines in Amer. Mus. 13769, a male character. (5) Length of skull, occiput to incisors, .341. (6) Length of Mtc. III .181; (7) Mtc. V a nodule instead of a short splint. (8) Nearest affinities with the relatively large, massively proportioned, brachyodont *P. nebrascencis* group.

MERYCOCHŒRUS-PARAHIPPUS ZONE. 8. LOWER MIOCENE.

THIS ZONE IS TYPIFIED BY THE UPPER HARRISON OF WESTERN NEBRASKA AND THE UPPER ROSEBUD OF SOUTH DAKOTA. IT ALSO EXTENDS INTO NORTHEASTERN COLORADO, INTO WYOMING, TEXAS, AND MONTANA THE HORSES BELONG TO THE GENUS *PARAHIPPUS*, NOW ATTAINING LARGE SIZE, AND BEGINNING TO APPROXIMATE THE MIDDLE MIOCENE STAGES.

Parahippus nebrascensis Peterson 1907.

Text Fig. 55.

Parahippus nebrascensis sp. nov., Peterson, O. A. "The Miocene Beds of Western Nebraska and Eastern Wyoming and their Vertebrate Faunae," *Ann. Carnegie Mus.*, Vol. IV, No. II, July, 1907, pp. 57–60, Pl. xix.

Horizon and locality.— "Upper Harrison beds on Niobrara River, in Sioux County, Nebraska." Merycochœrus zone. Collected by O. A. Peterson.

Type.— Carnegie Mus. 1440. (Peterson) "This species is based on a skull with the left mandible practically complete, the pelvis, the right femur, tibia, calcaneum, astragalus, and the proximal end of a metapodial of one individual." Measurements: (Peterson) occiput to incisors .370; length of p^1–m^3 .222; p^{1-4} .072; m^{1-3} .064.

Type figure.— Text Fig. 55 of this Memoir.

Characters.— (Peterson, 1907) (1) An animal of large size. (2) Premolars of proportionately large size when compared with molars, p^2 the longest tooth of premolar series; (3) protostyle of p^2 unusually well developed; (4) posterointernal tubercle of m^2 [hypostyle] more highly developed than in *P. texanus.* (5) Lachrymal fossa plainly indicated; (6) anterior border of orbit opposite anterior portion of m^3; (7) orbit closed posteriorly.

(Osborn, 1918) (1) Hypostyle of molars and premolars subtriangular; (2) crochet developed on metaloph of p^4, m^3; (3) metaloph uniting throughout grinding series, p^2–m^3, with ectoloph; (4) dentition brachyodont, robust.

(Matthew, 1913) Referred upper and lower jaws, Amer. Mus. 12924, from the Upper Rosebud, agree very closely with Peterson's type, being only slightly inferior in detailed measurements.

Parahippus pawniensis atavus subsp. nov.

Plates 38, 39.9,13. Text Fig. 56.

Horizon and locality.— Upper Harrison formation, near Agate, western Nebraska, Merycochœrus zone. Type collected by American Museum Expedition of 1908.

Type.— Amer. Mus. 14233. Occiput of skull with a considerable part of the skeleton, in excellent preservation, C 1, 4–7, dorsals, fore and hind limbs. Measurements: height of occiput .066; length of humerus .144; length of radius .174; Mtc. III .138; length of femur .207.

Type figure.— Plates 38, 39.9,13, text Fig. 56 of this Memoir.

Characters.— (Matthew, 1913, Osborn 1918) (1) Size of the type of *Parahippus pawniensis.* (2) Pes slender, lateral digits relatively unreduced; (3) Mts. III somewhat smaller than in the type of *P. pawniensis*, with smaller cuboid fossette; (4) lateral digits as in *P. pawniensis;* (5) limbs moderately long; (6) ulna slender, separate throughout; (7) manus moderately long, lateral digits not greatly reduced; (8) Mtc. V a small splint; (9) phalanges longer relatively than in *Miohippus;* (10) ungual phalanges narrow; (11) Mts. III articulation with cuboid oblique, broader and better defined than in *Miohippus.* (12) Occiput high and narrow; (13) condylar facets extended over basioccipital; (14) occipital surface separate and distinct.

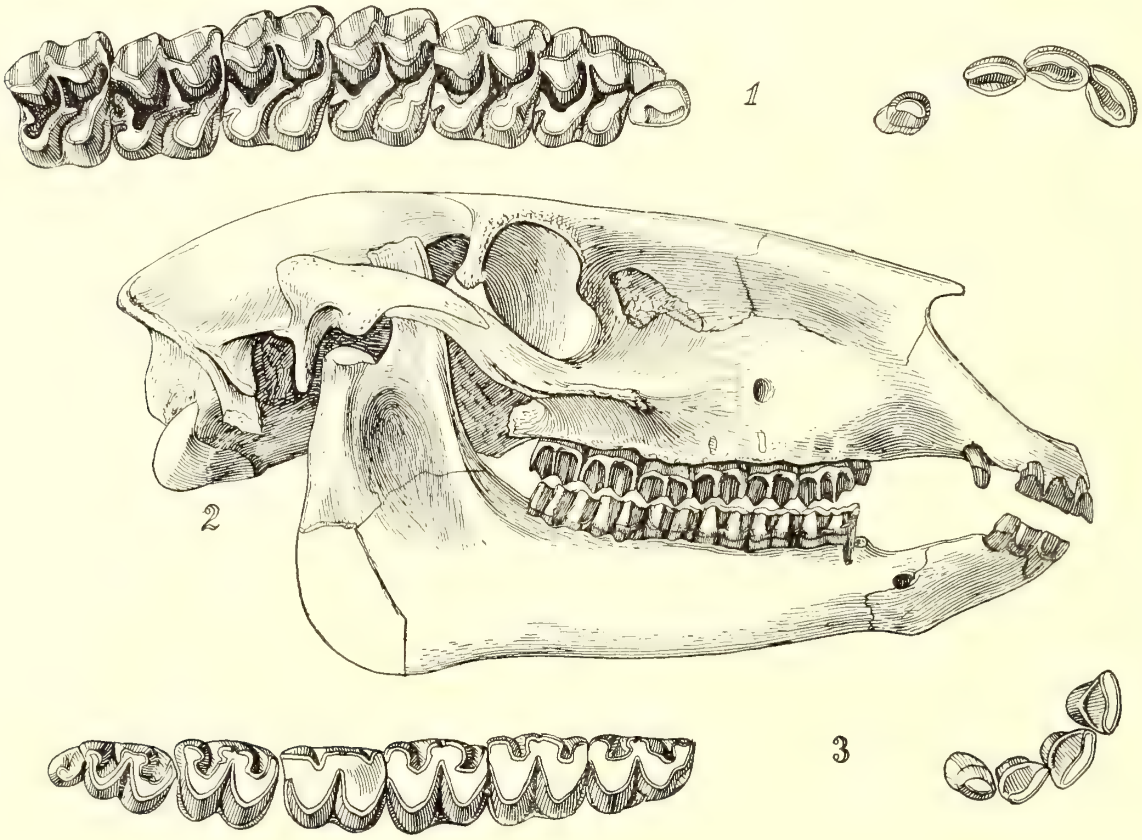

Fig. 55. Original figures of skull and dentition of type of *Parahippus nebrascensis* Peterson, Carnegie Mus. 1440. (1) Superior incisors and grinders, two-thirds natural size; (2) skull a little over one-third natural size; (3) lower incisors and grinders, about two-thirds natural size. After Peterson, 1907, Pl. xix.

Parahippus nebrascensis primus subsp. nov.

Plates 6.6,7, 8.2, 9.9. Text Fig. 57.

Horizon and locality.— Upper Harrison formation, upper Niobrara River, western Nebraska. Merycochœrus zone. Type collected by T. F. Olcott, 1907.

Type.— Amer. Mus. 13770. Skull and jaws. Measurements: total length occiput to incisors .390; condyles to incisors .363; superior dentition .221; superior premolar series, .077; superior molar series .064.

Type figure.— Plates 6.6,7, 8.2, 9.9, text Fig. 57 of this Memoir.

Characters.— (Matthew, 1913, Osborn 1918) (1) Distinctions in cranial and dental proportions from type of *P. nebrascensis* are partly due to crushing of the latter type. (2) A distinct crochet on p^{2-3} absent in *P. nebrascensis* type; (3) anteroposterior diameters of grinding teeth throughout equalling or exceeding those of *P. nebrascensis* type; (4) transverse diameters of grinding teeth, especially of the molars, greater throughout. (5) Orbit farther back, anterior border above middle of m^3 while in *P. nebrascensis* it is above anterior end of m^3; (6) diastema behind canine somewhat shorter.

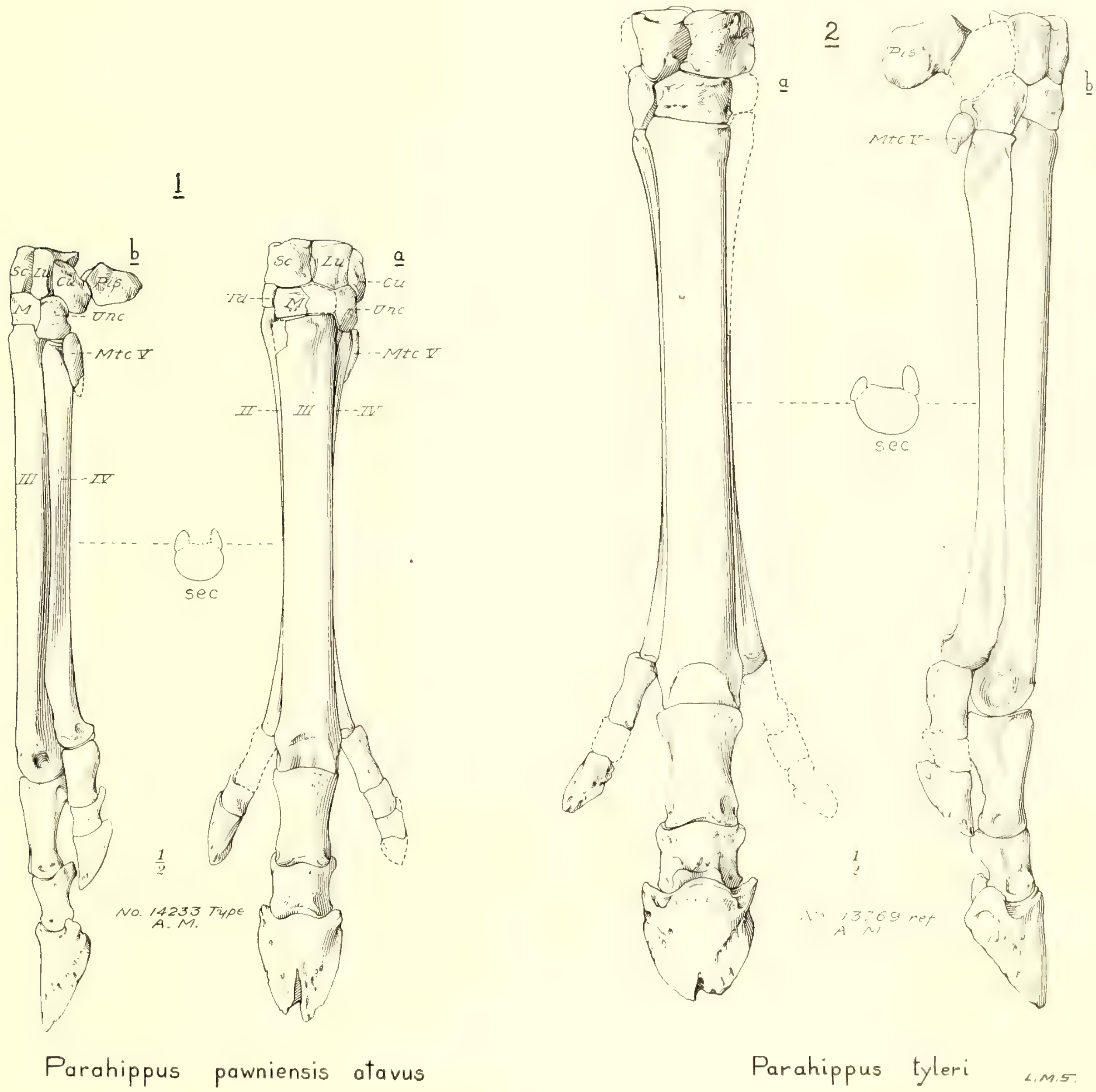

Fig. 56. THE FORE FOOT OF *PARAHIPPUS*. ANTERIOR AND EXTERNAL VIEWS OF MANUS IN *P. PAWNIENSIS ATAVUS* OSBORN AND *P. TYLERI* LOOMIS, AND SECTION THROUGH METACARPALS.

(Left) *P. pawniensis atavus*, Amer. Mus. 14233, manus of type, a small species, the lateral digits moderately reduced, the fifth metacarpal a very short splint. (Right) *P. tyleri* Loomis, Amer. Mus. 13769, referred specimen, a large animal, rather heavily proportioned, lateral digits moderate, the fifth metacarpal a small nodule. All figures one-half natural size.

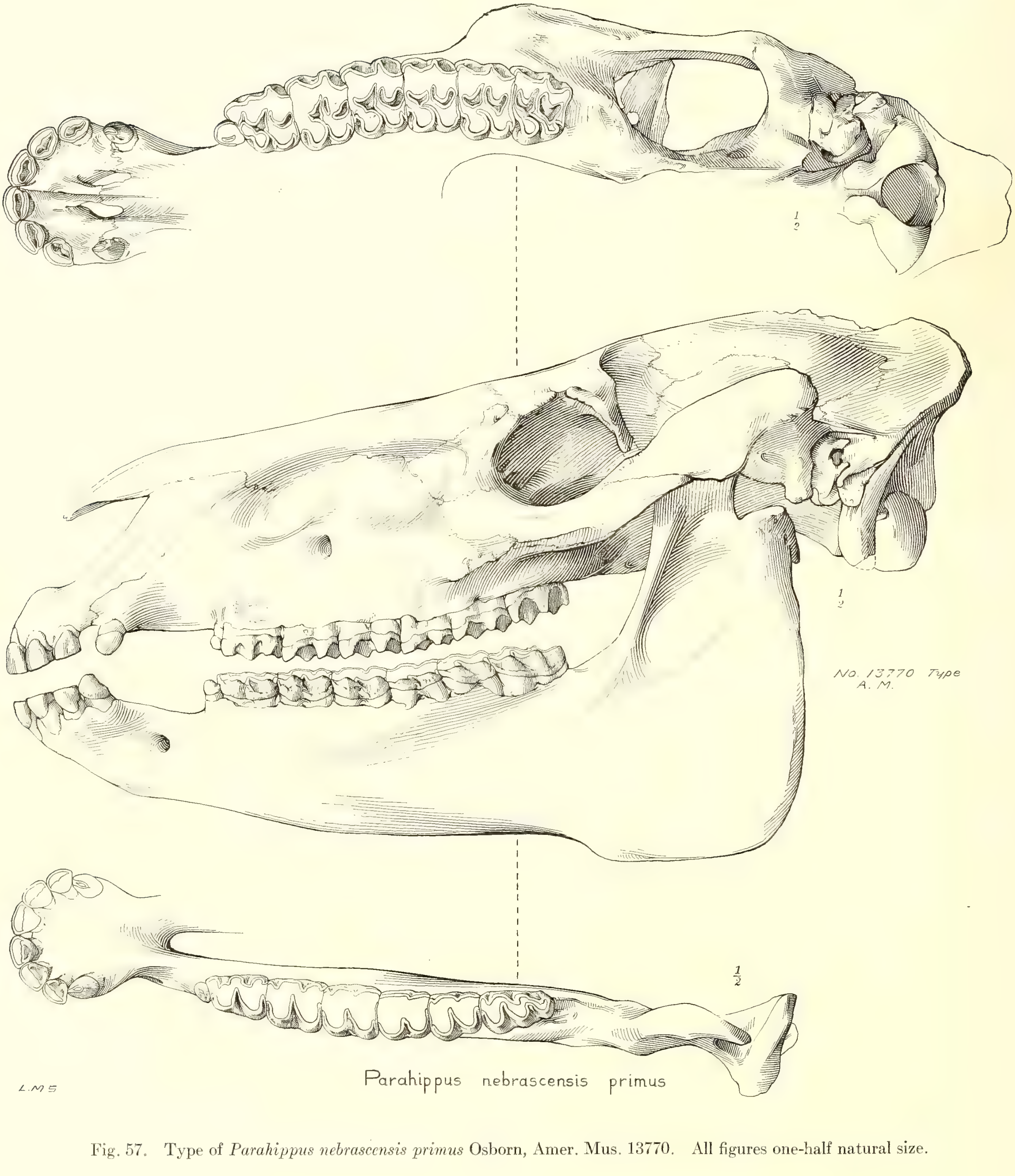

Fig. 57. Type of *Parahippus nebrascensis primus* Osborn, Amer. Mus. 13770. All figures one-half natural size.

Parahippus coloradensis præcurrens subsp. nov.

Plates 8.1, 9.1, 36.2,3. Text Fig. 58.

Horizon and locality.— Upper Rosebud formation, Shannon County, South Dakota, Merycochœrus zone. Type collected by Thomson, American Museum expedition of 1906.

Type.— Amer. Mus. 13018. Upper grinding teeth, p^2–m^3, and hind foot. *Paratype.* Amer. Mus. 12925. A lower jaw fragment with premolars, parts of tibia and radius, fore foot and both hind feet.

Type figure.— Plate 9.1, text Fig. 58 of this Memoir.

Characters.— (Matthew 1913, Osborn 1918) (1) Size of *Parahippus texanus*, one-eighth smaller than *P. nebrascensis*. (2) Crochet absent on p^2, strong on p^3–m^3; (3) p$_1$ and probably p^1 relatively large, compressed, p$_1$ with distinct heel; (4) metastylids imperfectly separated from metaconids. (5) Limbs and feet relatively slender, with (6) lateral metapodials greatly reduced.

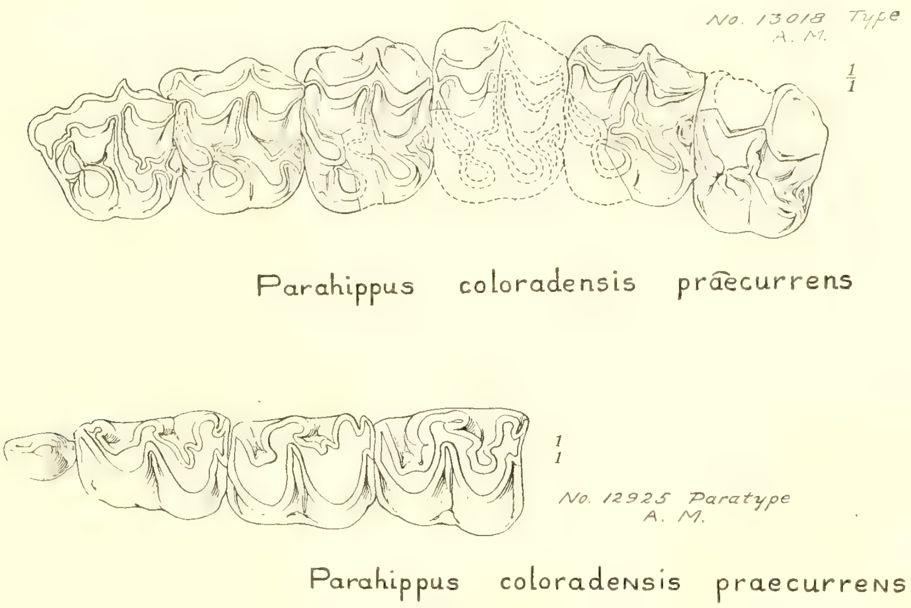
No. 13018 Type
A. M.
1/1
Parahippus coloradensis prāecurrens
1/1
No. 12925 Paratype
A. M.
Parahippus coloradensis praecurrens

Fig. 58. *Parahippus coloradensis præcurrens* Osborn. (Upper) Left superior premolar-molar series of type, Am. Mus. 13018, crown view. (Lower) Left inferior premolars (p$_{1-4}$) of Amer. Mus. 12925, paratype, crown view. Both figures natural size.

In the hypsodontism of its grinding teeth this animal is allied to the type of *P. coloradensis* Gidley, but is distinguished (1) by the greater separation of the metastylids, especially on p$_2$, and (2) by the relatively small size of p$_2$. The cotype lower jaw indicates an animal slightly smaller in size than the type of *P. nebrascensis*, with teeth narrower and more hypsodont, external cingula incomplete, p$_1$ more elongate and having a distinct heel. The limbs are slender and the feet are long, with the lateral digits greatly reduced. The radius is actually longer than in any *Hipparion* and much longer than that of any *Merychippus;* the ulna is separate throughout. The fore feet are proportioned as in *H. whitneyi* but only seven-eighths as large. Mtc. V is a diminutive nodule. The pes is long and slender like that of *H. whitneyi* but only three-fourths as large; the lateral digits are reduced to very slender, thread-like splints; the phalanges are shaped like those of *Hipparion* and *Merychippus*.

Parahippus texanus Leidy 1868.

Plates 8.3, 9.10. Text Fig. 59.

Anchippus texanus, Leidy, Joseph. "Notice of Some Remains of Extinct Pachyderms," *Proc. Acad. Nat. Sci. Phila.*, Vol. XX, 1868, pp. 231–232, no figure. "The Extinct Mammalian Fauna of Dakota and Nebraska," *Jour. Acad. Nat. Sci. Phila.*, (2) Vol. VII, 1869, pp. 312–313, Pl. xxi, fig. 13.

Horizon and locality.— (Leidy, *Proc.* 1868, p. 231.) "It was obtained from 'Hutchen's well,' from a yellow sandstone, supposed to be of Miocene age, at a depth of 50 feet below the surface, in Washington County, Texas." Possibly Middle Miocene. Name of collector not given. The Lower Miocene age of *P. texanus* is inferred from the referred specimens, including an incomplete upper molar from the Upper Martin Cañon beds, Logan County, Colorado, a stage belonging to the upper division of the Lower Miocene, Merycochœrus zone (W. D. M. 1913).

Type.— Acad. Nat. Sci. Phila. Coll. (Leidy, 1868) A portion of a superior molar tooth, m^1 or m^2, lacking the outer wall of the ectoloph. Measurements: (Gidley, 1907, p. 886) the measurements of the tooth are: anteroposterior diameter, .019; transverse diameter .020+.

Type figure.— Text Fig. 59 of this Memoir.

Characters.— (Leidy, 1868, 1869, Osborn, 1918) (1) Ectoloph of same form as in *Anchitherium;* (2) inner lobes [protocone and hypocone] proportionately less robust; (3) median lobes [protoconule, metaconule] proportionately more robust; (4) posteromedian lobe [metaloph] joining outer lobes [ectoloph]; (5) from middle of metaloph a process [crochet] given off. (6) (Leidy, 1868, p. 232) "This process looks as if disposed to join the contiguous portion of the antero-median lobe, together with it to form a crescentoid lobe, embracing the antero-external one, as in the corresponding columns of equine teeth. No such arrangement exists in *Anchitherium.* [7] A triangular tubercle, as in the latter genus, occupies the space at the back of the crown, and it appears as if its anterior angle had a disposition to join the contiguous portion of the postero-median lobe [metaloph], to form with it a crescentoid lobe, in like manner as in the former case, to embrace the postero-external lobe." (8) Strong anterointernal cingulum embracing protocone; (9) protoloph interrupted, uniting with parastyle.

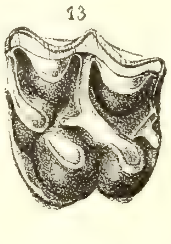

Fig. 59. Original figure of the type of *Parahippus texanus* Leidy, Acad. Nat. Sci. Phila. Coll., a portion of a superior molar tooth, m^1 or m^2, lacking the outer wall of the ectoloph. Natural size. After Leidy, 1869, Pl. xxi, fig. 13.

Leidy's penetrating description of this fragmentary tooth, as largely quoted above in his own language, is prophetic of the transition of the *Parahippus* into the *Merychippus* type of molar. As he observes in his final description (1869, p. 313) "The tooth, from its structure, is evidently intermediate to those of *Merychippus* as a representative of the *Equidæ*, and those of *Anchitherium.*"

Referred specimen, Amer. Mus. 12924.

Parahippus australis Leidy 1873.

Text Fig. 60.

Anchitherium (?) *australe*, Leidy, Joseph. "Contributions to the Extinct Vertebrate Fauna of the Western Territories," *Rept. U. S. Geol. Surv. Terr.* F. V. Hayden, Vol. I, Pt. I, 1873, pp. 250–251, Pl. xx, fig. 19.

Horizon and locality.— A well at Independence, Washington County, Texas, Upper Miocene. The type was found in association with a second or third upper molar (*op. cit.* pl. xxii, fig. 16) of the right side which was provisionally referred by Leidy to the species *Protohippus perditus* (?) which is an Upper Miocene stage. Name of collector not given.

Type.— Acad. Nat. Sci. Phila. Coll. Second upper premolar of the right side. As described by Leidy (1873, p. 250) "It is the first of the series of six large upper molars as existing in equine animals, but exhibits in front the impress of a premolar [p^1] larger than usual in members of the order. The specimen is broken at its outer part, but the remainder is nearly as characteristic as if the whole were complete." Measurements: (Leidy, p. 251) "The estimated size of the tooth is 11 lines in diameter anteroposteriorly and nearly the same measurement transversely."

Type figure.— Text Fig. 60 of this Memoir.

Characters.— (Leidy, 1873, Osborn, 1918) (1) An oblique valley extends from the inner side and ends in a foot-like expansion [parastyle]; (2) back of the center of the triturating surface a crescentic enamel lake [post-fossette]; (3) devoid of cement; (4) inner and intermediate lobes [protocone, hypocone] somewhat fuller than in *Anchitherium;* (5) resembling *Anchippus* in other features but differing from both *Anchippus* and *Parahippus* in the absence of the crochet [a fold which may be worn off]. The tooth also resembles the type of *Hypohippus* in (6) the uncertainty as to its generic relationship. Leidy refers it to *Anchitherium.*

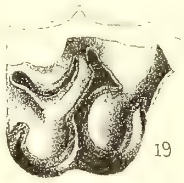

Fig. 60. Original figure of the type of *Parahippus australis* Leidy, Acad. Nat. Sci. Phila. Coll., p^2 of the right side. Natural size. After Leidy, 1873, Pl. xx, fig. 19.

Parahippus taxus Douglass 1908.

Text Fig. 62.

Altippus taxus gen. et sp. nov., Douglass, Earl. "Fossil Horses from North Dakota and Montana," *Ann. Carnegie Mus.*, Vol. IV, Nos. III, IV, Apr., 1908, pp. 271–273, pl. LXVII, figs. 3, 4, Pl. lxviii, figs. 6–8.

Horizon and locality.— Near Woodin Station, on Divide Creek, about six miles south of the continental divide, Silver Bow County, Montana. Zone of *Entoptychus*, therefore Upper Oligocene or Lower Miocene. Type collected by Earl Douglass, 1905.

Type.— Carnegie Mus. 836 (Douglass). "The type. . . .consists of parts of a skull, the greater portion of a mandible, a radius, portions of two femora, a tibia, a nearly complete hind foot, other bones of toes, and numerous fragments." An immature animal, dp^{2-4}, m^3 unformed. Measurements: dp^1–m^2 .088; m^1 a. p. .015, tr. .018, height of crown .013.

Type figure.— Text Fig. 62 of this Memoir.

Characters.— (Douglass, 1908, Osborn, 1918) (1) Metaloph separate from ectoloph; (2) protoloph and metaloph of m$^{1-2}$ rather sharp and continuous; (3) protoconule small but well defined; (4) no crochet indicated on metaloph, in which metaconule is very faintly indicated; (5) hypostyle moderately large, subtriangular; (6) parastyle small; (7) mesostyle sessile and thin; (8) faint ridges on paracone and metacone. (9) Limbs elongate, metapodials unusually long and slender, metatarsals nearly the same length as the radius; (10) ungual phalanges long and narrow; (11) tibia nearly one-fourth longer than radius; (12) pes anisotridactylous.

Douglass observes (p. 273): "A remarkable characteristic of this horse is the extreme length and slenderness of the limbs combined with the primitive pattern of the teeth, which, with the exception of the somewhat greater height of the different elements. . . . are scarcely more progressive, . . . than are the teeth of some of the horses of the Lower Oligocene."

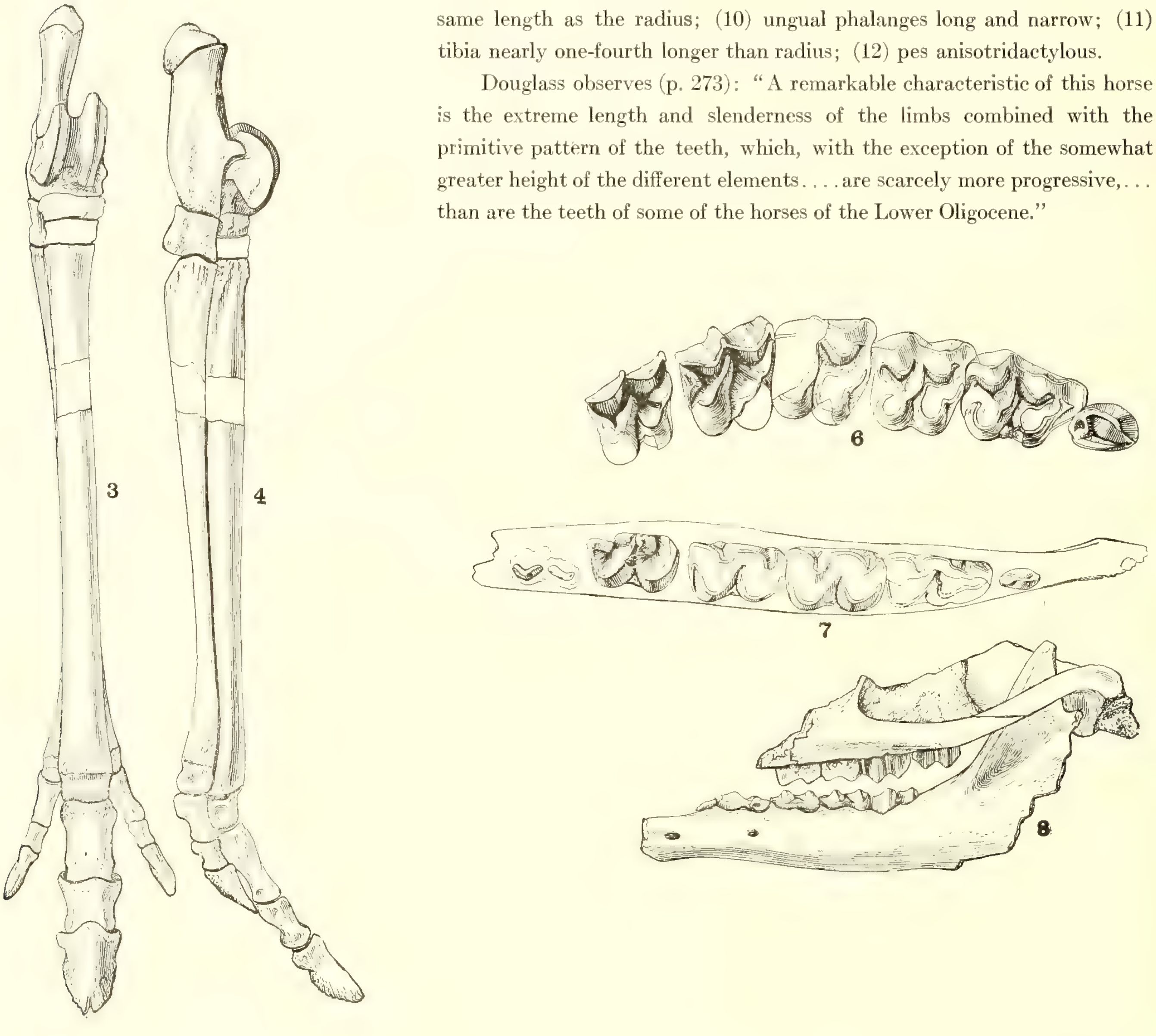

Fig. 62. Original figures of parts of the type of *Parahippus taxus* Douglass, Carnegie Mus. 836. (3, 4) Right pes (6, 7) crown and side views of deciduous premolars, also m$^{1-2}$. (8) Skull. After Douglass, 1908, Pl. lxvii. Skull and limb bones one-half natural size, teeth natural size.

Parahippus agrestis Leidy 1873.

Text Fig. 63.

Anchitherium agreste, Leidy, Joseph. "Contributions to the Extinct Vertebrate Fauna of the Western Territories," *Rept. U. S. Geol. Surv. Terr.*, F. V. Hayden, Vol. I, Pt. I, 1873, pp. 251–252, Pl. vii, figs. 16, 17.

Horizon and locality.— (Leidy) " . . . imbedded in an indurated, gray, arenaceous marl, . . . derived from a lacustrine Tertiary deposit on Red Rock Creek, one of the head branches of the Jefferson Fork of the Missouri River." Montana. Type collected by F. V. Hayden, 1871.

Type.— U. S. Nat. Mus. 5393. Lower jaw fragments containing lower last premolar and first molar of the left side, also last molar from the same specimen as the former. Measurements: (Leidy) space occupied by the back four molars 34 lines; space occupied by the back three molars 27 lines; m_1 a. p. 7–$\frac{3}{4}$ lines, tr. 7 lines.

Type figure.— Text Fig. 63 of this Memoir.

Characters.— (Leidy, 1873) (1) Approaching in size the *A. aurelianense;* (2) identical in form with *Mesohippus* (*A.*) *bairdii* and *A. aurelianense;* (3) nearly according in size with *Miohippus* (*A.*) *condoni.*

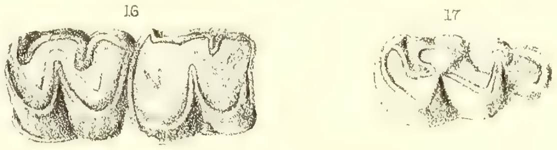

Fig. 63. Original figures of the lower molar teeth (p_4, m_1, m_3) of the type of *Parahippus agrestis* Leidy, U. S. Nat. Mus. 5393. Natural size. After Leidy, 1873, Pl. vii, figs. 16, 17.

TICHOLEPTUS-MERYCHIPPUS ZONE. 9. EARLY MIDDLE MIOCENE.

This zone is typified by the Mascall of Oregon, and, as described above, is widely distributed in Montana, Colorado, western Nebraska, and Texas, with possible outlyers in California. It is distinguished by the first appearance of *Merychippus*, surviving *Parahippus*, *Kalobatippus*, and the hitherto unrecognized form *Archæohippus*.

Parahippus avus Marsh 1874.

Plates 6.7, 8.6,9,10, 9.4. Text Figs. 64, 65.

Protohippus avus, sp. nov., Marsh, O. C. "Notice of New Equine Mammals from the Tertiary Formation," *Amer. Jour. Sci. and Arts*, (3), Vol. VII, No. 39, Mar., 1874, pp. 253–254, no figure.

Horizon and locality.— Cottonwood Creek of the John Day River, Oregon, type locality of the Mascall formation, Middle Miocene. Type collected by Thomas Condon. The geologic horizon of this specimen is doubtful; it probably belongs to the Upper John Day rather than to the Mascall.

Type.— Yale Mus. 11281. (Lull, R. S., letter Oct. 23, 1915.) The type consists of portions of both lower jaws, the right bearing p_{2-4}, m_{1-2}, the left p_{2-4} and m_1. There are also nine upper molar and premolar teeth, chiefly of the left side, at least one incisor, and a few tooth fragments. Measurements: (Marsh) space occupied by six upper molars .110, space occupied by three upper premolars, .057, antero-posterior diameter of second upper premolar, .023, transverse diameter, .022, antero-posterior diameter of last upper molar, .017, transverse diameter, .022, extent of three lower premolars .0575, antero-posterior diameter of first lower premolar, .0205, transverse diameter, .015, antero-posterior diameter of first lower true molar, .018, transverse diameter, .016.

Type figure.— Plates 8.9,10, text Fig. 64.

Characters.— (Marsh, p. 254) "The molar teeth have very short crowns, and are inserted by distinct fangs. The enamel is covered with a thick coat of cement. The molars are considerably worn, and the pattern of the enamel thus produced nearly resembles that in the corresponding teeth of *Anchitherium*, with which the present teeth agree, also, in form and arrangement. . . . The outer concavities of the external lobes are without any median elevation. The posterior inner cone is larger than the one in front. All the lower molars have an outer basal ridge."

(Osborn, 1918) The type (Yale Mus. 11281) includes p$^{2-4}$, m^2, and jaw with p$_2$–m$_2$. (1) The crowns are very low, much as in *Miohippus gemmarosæ;* (2) a rudimentary crochet appears on m^2, none is apparent on the premolars; (3) very little cement on the teeth, far less than on any species of *Merychippus;* (4) the sides of the teeth are smooth, resembling those of *Kalobatippus.*

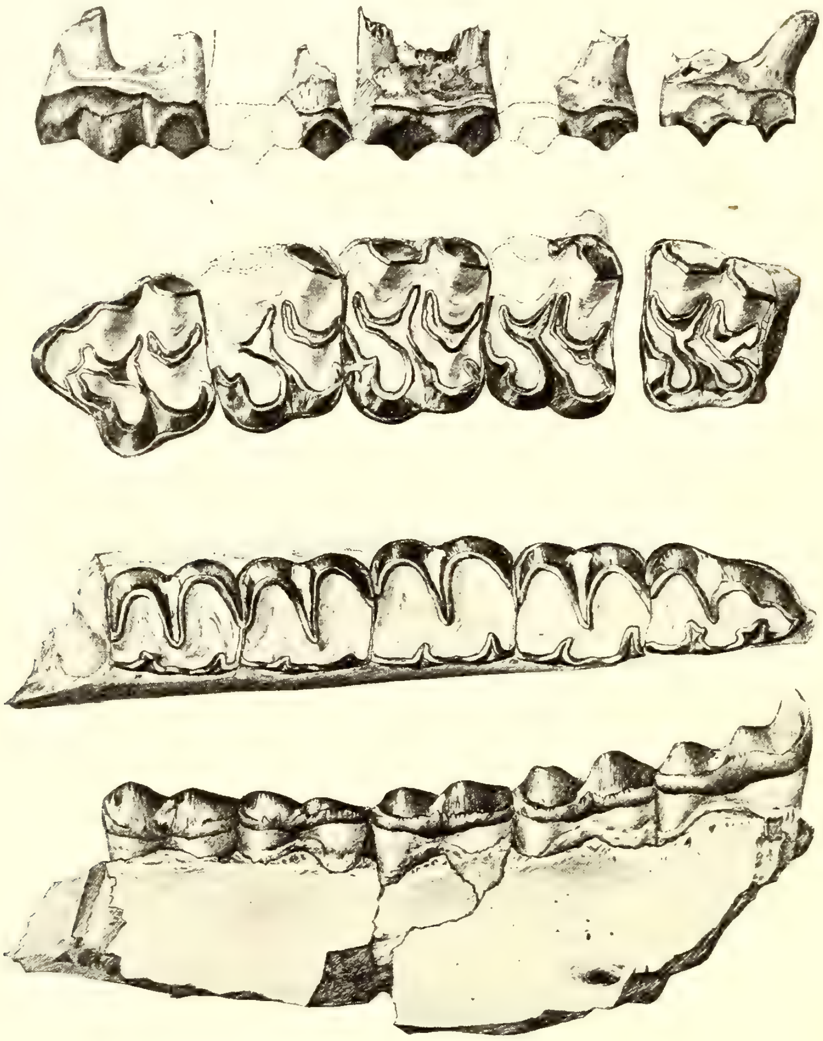

Fig. 64. Type of *Parahippus avus* Marsh, Yale Mus. 11281. (Two upper figures) Superior grinding teeth, p^2–m^1, of the left side, m^3 reversed from the right side; external and crown views. (Two lower figures) Crown and side views of fragmentary right mandible of type containing p$_2$–m$_3$, external and crown views. All figures natural size. Drawing by B. Yoshihara.

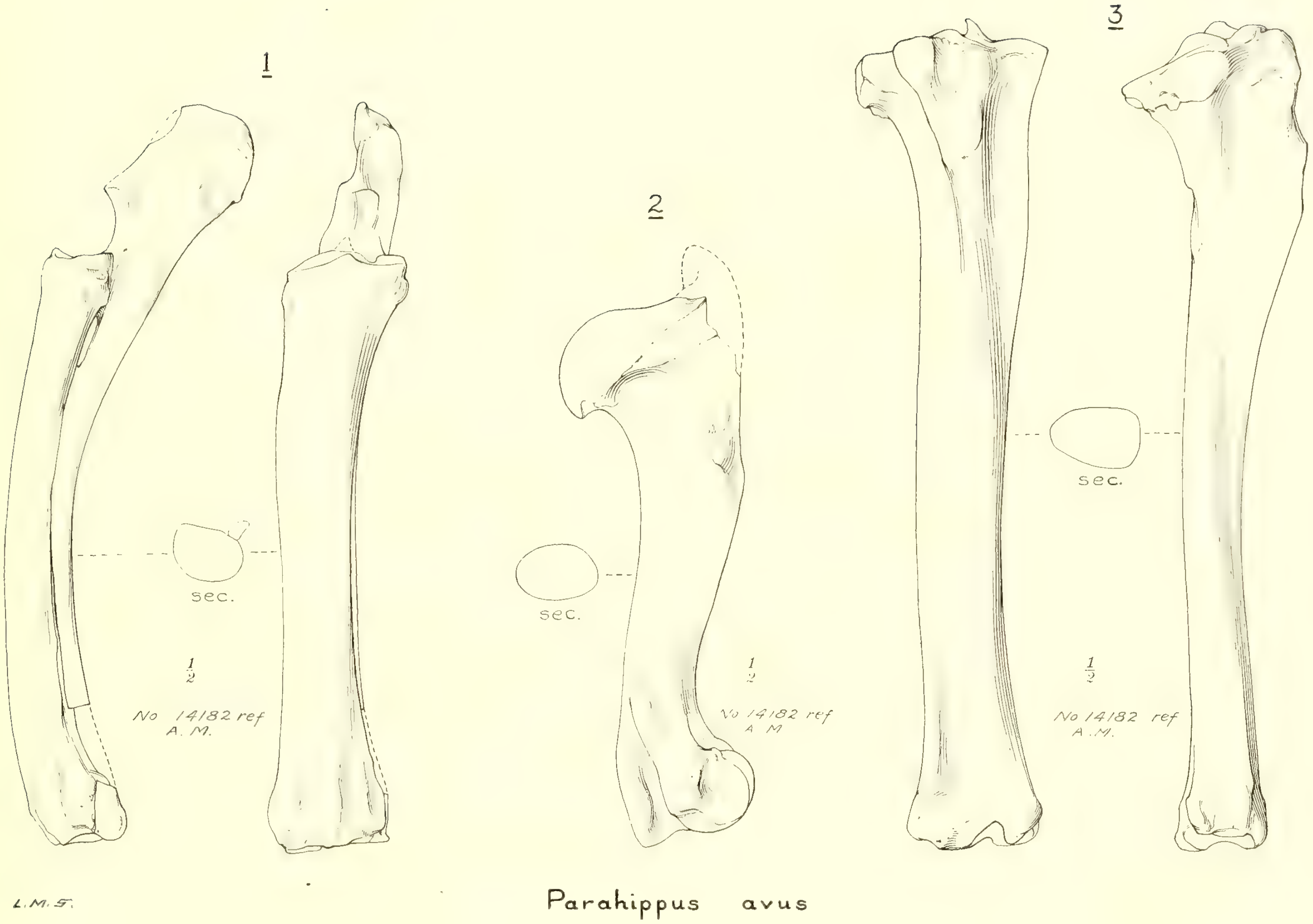

Fig. 65. *Parahippus avus* Marsh, Am. Mus. 14182, referred specimen. (1) Ulna and radius, outer and front views. Ulnar shaft moderately slender, slightly coössified in middle portion although this skeleton is of an old individual. (2) Outer view of humerus. (3) Tibia, front and outer views. All figures one-half natural size.

Parahippus brevidens Marsh 1874.

Plate 8.11. Text Fig. 66.

Anchippus brevidens, sp. nov., Marsh, O. C. "Notice of New Equine Mammals from the Tertiary Formation," *Amer. Jour. Sci. and Arts*, (3), Vol. VII, No. 39, March, 1874, pp. 254–255, no figure.

Horizon and locality.— (Marsh) "Pliocene of Oregon." Probably Mascall formation of the John Day series, Cottonwood Creek, Middle Miocene. Name of collector not given.

Type.— Yale Mus. 11274. Three upper molar teeth, m^{2-3} of the left side, ?m^1 or p^4 of the left side. Measurements: (Marsh) m^2 a.p. .0175, tr. .022; m^3 a.p. .017, tr. .0125; height of unworn crown of m^3 .015.

Type figure.— Plate 8.11, text Fig. 66 of this Memoir.

Characters.— (Marsh, 1874, Osborn, 1918) (1) Antero-median lobe [protoconule] forwardly placed, hence its worn surface is not in the same line with that of the antero-internal lobe [protocone]; (2) posterior crescentoid tubercle [metaconule] isolated, wearing into an ear-shaped lobe, inclosing a pit [postfossette] with cement; (3) molar crowns unusually short [subhypsodont] even when unworn; (4) enamel of crown and of ectoloph [m^3] covered with cement; (5) outer lobes [paracone and metacone] with only a faint indication of the median ridge and their concave surfaces; (6) the buttresses [para-, meso-, and metastyles] enclosing these faces are prominent; (7) metaloph ptychoid on both sides; (8) m^3 small; (9) metaloph at an early stage of wear uniting with hypocone and not with hypostyle.

(W. D. M. 1913) This is a progressive, heavily cemented, and relatively large species of *Parahippus*. The characters enumerated above are shown in a somewhat less degree in the unworn teeth of other species of *Parahippus*. The distinctions between unworn and worn teeth are very marked in this stage of evolution.

(Osborn, 1918) This presents the closest approach to the *Merychippus isonesus primus* stage.

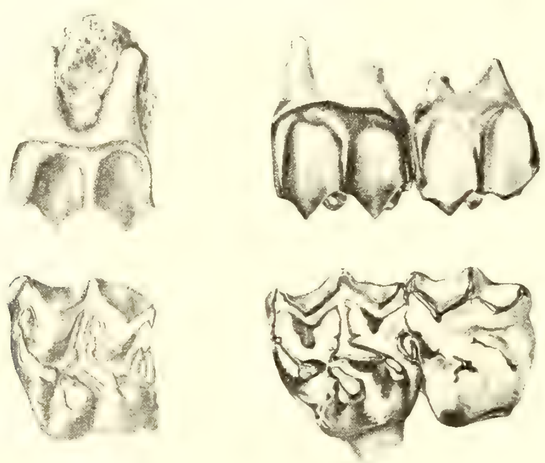

Fig. 66. *Parahippus brevidens* Marsh. (Right) Yale Mus. 11274, type, superior molars, m^{2-3}, of the left side. (Left) Referred molar, ?m^1, in the collection of the University of California. All figures natural size. Left hand drawings by B. Yoshihara, right hand by S. Oka.

Parahippus crenidens Scott 1893.

Plates 8.4, 9.2. Text Fig. 67.

Desmatippus crenidens sp. nov., Scott, W. B. "The Mammals of the Deep River Beds," *Amer. Naturalist*, Vol. XXVII, No. 319, July, 1893, p. 661, no figure. "The Mammalia of the Deep River Beds," *Trans. Amer. Philos. Soc.*, N. S. Vol. XVIII, 1894, p. 84, Pl. ii, figs. 9–14.

Horizon and locality.— Deep River valley, Montana, upper strata of the Deep River formation, Middle Miocene. Type collected by Mr. I. Benet.

Type.— Princeton Mus. 10430 (cast Amer. Mus. 10782). (Scott, 1894, p. 84) "The type specimen of the new genus consists of the dentition of both jaws, lacking the incisors, canines, first lower premolar and last upper molar, the mandible, portions of the radius and ulna, femur, manus and pes, and fragments of other bones." Measurements: p^1–m^3 .117; p^{1-4} .068; m^{1-3} .049.

Type figure.— Text Fig. 67 of this Memoir.

Characters.— (Scott, 1893, p. 661) "Posterior transverse crests of upper cheek teeth sinuous; limbs elongate and slender; size moderate." *Generic characters.* (Scott, 1894, p. 84) Molars and premolars short crowned, the valleys more or less filled with a thin deposit of cement. In the upper series the posterior transverse crest [metaloph] is connected with the outer wall [ectoloph] and sends forward a process [crochet] which extends nearly to the anterior conule [protoconule]. Inner cusps of lower teeth expanded so as to narrow the entrances to the valleys. Median inner cusps (a, a^1 of Rütimeyer) much more distinctly separated than in the older genera.

From this clear description and the type figures may be added: (1) anterior enamel border in the region of the crochet crenulate or ptychoid; (2) hypostyle triangular, well developed; (3) cingulum feebly developed on outer wall of p_2–m_1.

(Osborn, 1918) (1) Grinding teeth brachyodont; (2) superior premolars with little cement; (3) cement on ectoloph and in upper and postfossettes of m^3, also in outer valleys of p_2–m_2; (4) lower premolars and molars with strong external cingulum; (5) internal cingulum on superior premolars; (6) metaloph of m^1 longer than protoloph; (7) hypostyle subtriangular; (8) crochet on m^3, probably worn from other teeth; (9) metaloph and protoloph uniting with ectoloph; (10) external ribs slightly developed. This animal agrees with the *P. nebrascensis* group of *Parahippus* except that (11) it exhibits cement on the grinding teeth.

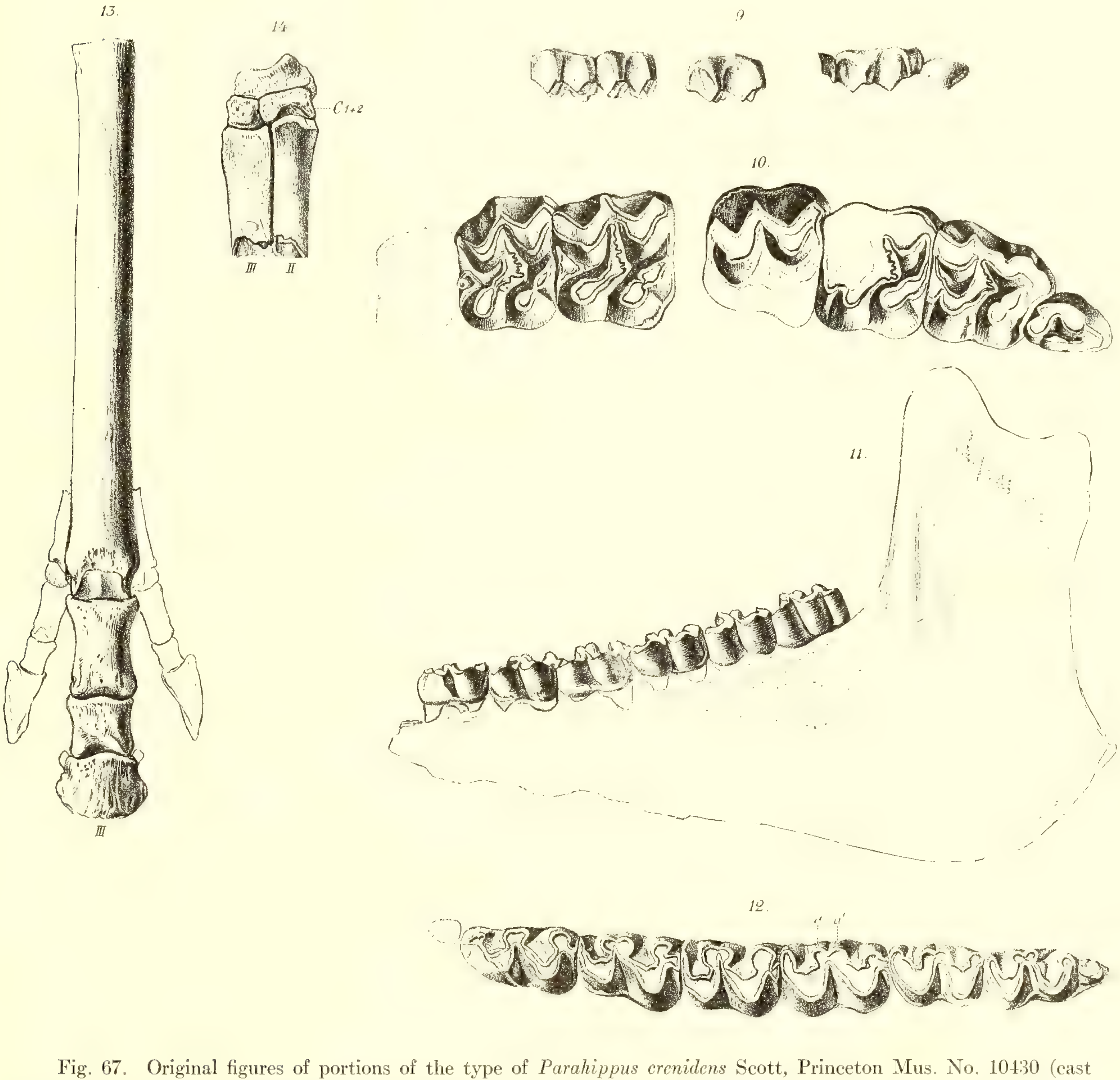

Fig. 67. Original figures of portions of the type of *Parahippus crenidens* Scott, Princeton Mus. No. 10430 (cast Amer. Mus. 10782). (10) Superior grinding teeth, p^{1-4}, m^{1-2}, natural size; (9) external view of same, two-thirds natural size. (11) External view of mandible, two-thirds natural size. (12) Crown view of inferior molar teeth, p^2–m^3, natural size. (13) Lower portion of manus, one-half natural size. (14) Inner view of right tarsus, one-half natural size. After Scott, 1894, Pl. ii.

(Matthew, 1913) A doubtfully referred specimen, Amer. Mus. 14182 from the Sheep Creek beds of Nebraska, of somewhat earlier geologic age than the Mascall, consists of part of the skull, jaws, and a large part of the skeleton. This agrees with the type in the presence of cement, and agrees with various species of *Merychippus* in the abbreviation of the metapodials, measuring Mtc. III .165.

MERYCHIPPUS PANIENSIS - M. SEJUNCTUS ZONE. 10. LATE MIDDLE MIOCENE.

THIS LIFE ZONE IS TYPIFIED BY THE PAWNEE CREEK OF NORTHWESTERN COLORADO, WHICH CONTAINS A GREAT VARIETY OF *MERYCHIPPUS.*

Parahippus pawniensis Gidley 1907.

Plates 8.5, 9.3. Text Figs. 68, 69.

Parahippus pawniensis sp. nov., Gidley, J. W. "Revision of the Miocene and Pliocene Equidæ of North America," *Bull. Amer. Mus. Nat. Hist.*, Vol. XXIII, Art. XXXV, Nov. 26, 1907, p. 932, no figure.

Horizon and locality.— Cedar Creek, Pawnee Creek formation, northeastern Colorado, Middle Miocene. Type collected by Handel T. Martin, American Museum Expedition of 1898.

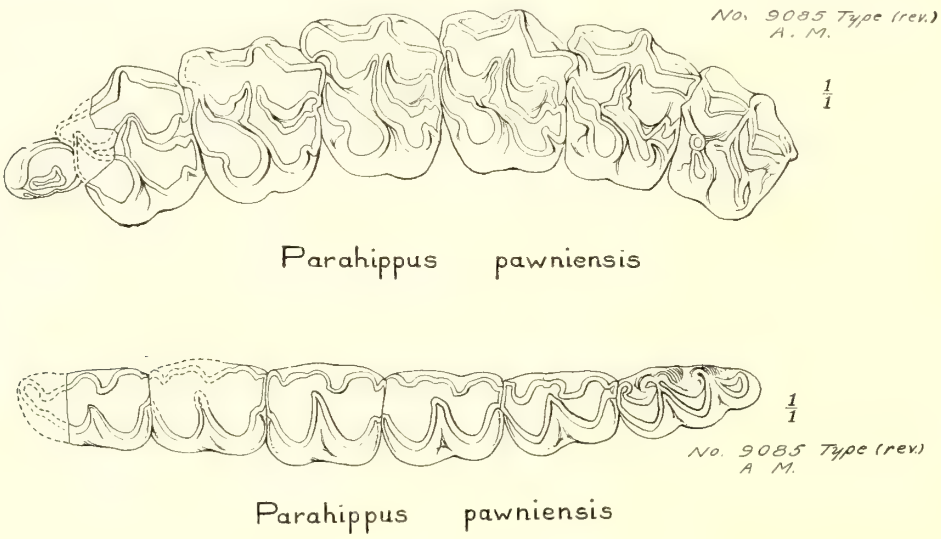

Fig. 68. *Parahippus pawniensis* Gidley, Amer. Mus. 9085, crown view of the upper and lower dentition of the type. Natural size.

Type.— Amer. Mus. 9085. The upper and lower cheek teeth of one side, and fragments of the skeleton, including parts of the feet. Measurements: (Gidley) p^2–m^3 (approximately) .092; m^{1-3} .0462; p^4 a. p. .072, tr. .0201; m^1 a. p. .0178, tr. .020.

Type figure.— Plates 8.5, 9.3, text Fig. 68 of this Memoir.

Characters.— (Gidley, 1907, p. 932) "(1) Cheek teeth shorter crowned than in any other species hitherto described; (2) the metaloph in the upper teeth is comparatively straight, with enamel walls simple except for the median anterior fold, or crochet; (3) crochet slightly united with the protoconule at its base; (4) external walls of paracone and metacone relatively flat, as in *P. crenidens*, with only a faint indication of the median rib; (5) crowns of upper cheek teeth proportionately narrower than in *P. crenidens;* (6) the metastylid in the lower teeth less prominent and less distinctly separated from the metaconid than in the other known species of this genus. This type apparently represents one of the least specialized species of the genus." (Osborn, 1918) (7) Crochet present on superior grinders and prominent, especially on m^{1-3}, consequently pre- and postfossettes early enclosed.

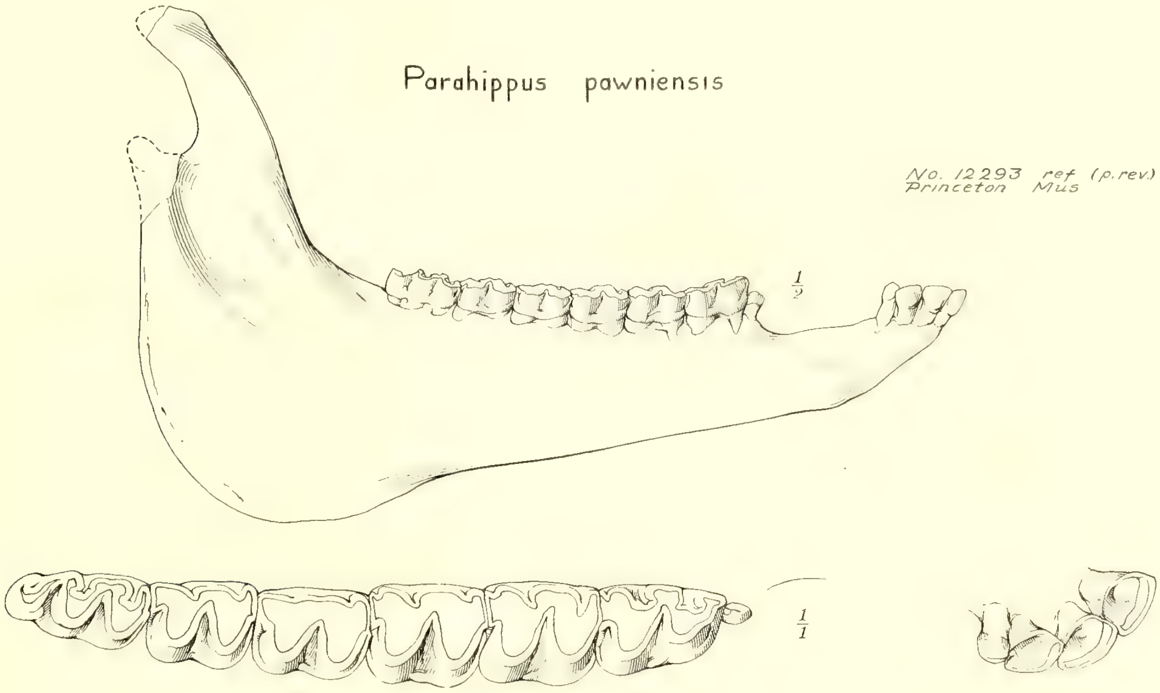

Fig. 69. Referred specimen of *Parahippus pawniensis* Gidley, Princeton Mus. 12293. Jaw one-half natural size, teeth natural size.

Parahippus coloradensis Gidley 1907.

Plates 8.7,12. Text Fig. 70.

Parahippus coloradensis sp. nov., Gidley, J. W. "Revision of the Miocene and Pliocene Equidæ of North America," *Bull. Amer. Mus. Nat. Hist.*, Vol. XXIII, Art. XXXV, Nov. 26, 1907, p. 932, no figure.

Horizon and locality.— Pawnee Creek, Logan County, northeastern Colorado, Pawnee Creek formation, Middle Miocene. Type collected by J. W. Gidley.

Type.— Amer. Mus. 9040. A single upper molar, m^3. Measurements: (Gidley) m^3 a.p. .016, tr. .0205, height of crown .0145. *Paratypes.* Amer. Mus. 9412, 8282. Two fragments of lower jaws containing teeth.

Type figure.— Plate 8.12, text Fig. 70 of this Memoir.

Characters.— (Gidley, 1907, p. 933) "(1) Larger than *P. pawniensis*, about equalling *P. crenidens* in size; (2) tooth crown comparatively high; (3) outer walls of paracone and metacone strongly ribbed; (4) metaloph with crochet well developed, the type tooth presenting two additional enamel folds; (5) the metastylid of the lower teeth well developed and separated from the metaconid by a well marked groove reaching nearly to the base of the crown. (6) On the external walls of the lower teeth the enamel is very rough, almost wrinkled in appearance."

(Osborn, 1918) The type, m^3, Amer. Mus. 9040, is quite distinctive, the crochet not being single but represented by two enamel folds. One of the lower jaws selected by Gidley as a paratype, Amer. Mus. 9412, belongs to an animal of larger size and probably a distinct species, consequently the above species characters (5 and 6), based by the author on these particular teeth, are invalid.

The characters presented in these teeth indicate a species of *Parahippus* somewhat more advanced in development than *P. crenidens*, and decidedly more specialized than *P. pawniensis*.

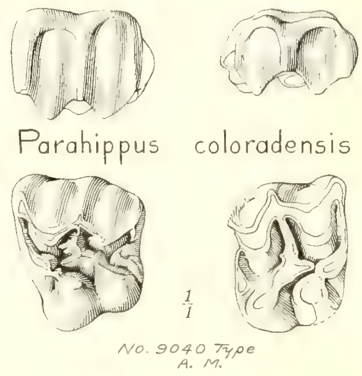

Fig. 70. Type of *Parahippus coloradensis* Gidley, Amer. Mus. 9040, m^3 of the left side, m^2 of the right side. Natural size.

PROCAMELUS-HIPPARION ZONE. 13. LOWER PLIOCENE.

THIS ZONE IS TYPIFIED BY THE EXPOSURES NEAR FORT NIOBRARA, NEBRASKA, AND IS WIDELY DISTRIBUTED IN THE WESTERN UNITED STATES. IT CONTAINS THE FINAL STAGES OF *PARAHIPPUS*.

Parahippus cognatus Leidy 1858.

Plates 8.8, 9.5, 25.2. Text Fig. 71.

Anchitherium (*Parahippus*) *cognatus*, Leidy, Joseph. "Notice of Remains of Extinct Vertebrata, from the Valley of the Niobrara River, collected during the Exploring Expedition of 1857, in Nebraska, under the command of Lieut. G. K. Warren, U. S. Top. Eng., by Dr. F. V. Hayden, Geologist to the Expedition," *Proc. Acad. Nat. Sci. Phila.*, Vol. X, 1858, p. 26, no figure. *Parahippus cognatus*, "The Extinct Mammalian Fauna of Dakota and Nebraska," *Jour. Acad. Nat. Sci. Phila.* (2) Vol. VII, 1869, p. 314, Pl. xxi, figs. 7–10.

Horizon and locality.— Niobrara River near Ft. Niobrara, Nebraska. Probably Procamelus zone, Lower Pliocene. Name of collector not given.

Type.— U. S. Nat. Mus. 567 (cast, Amer. Mus. 10772). Three upper milk molars of the left side, $dp^{2,3,4}$, also dp_2. (Leidy, 1869, p. 314) "The teeth all belonged to the same individual, and appear to pertain to the temporary series... The specimens consist of the upper molar teeth of the left side and the first lower molar of the right side." Measurements: (Gidley, 1907, p. 881) dp^2 a. p. .025, tr. .018; dp^3 a. p. .019, tr. .020; dp^4 a. p. .020, tr. .020.

Type figure.— Text Fig. 71 of this Memoir.

Characters.— (Leidy, 1858, p. 26) (1) The premolar teeth of the same form as the upper deciduous molars of *Mesohippus* (*Anchitherium*) *bairdii* or *A. aurelianense* except that the outer extremity of the prolongation of the postero-internal lobe [metaloph] branches into several short [crochet] folds. These latter have the same arrangement as the smaller but more numerous folds in the same position in *Merychippus*.

(Gidley 1907, p. 881) (1) Milk teeth brachyodont; (2) cement thin or wanting; (3) inner cones [pr, hy] larger than median conules [pl, ml].

(Osborn, 1918) Crochet complicated in dp$^{2, 3}$, simple in dp^4.

This specimen is very important as the genotype of *Parahippus*, and is noteworthy as recorded from a high geologic level while belonging to *Parahippus* as the genus is now understood. We must await the discovery of permanent teeth for the proper definition of the specific characters.

Referred to this species are (W. D. M.) Amer. Mus. 13919, 13943, 14322.

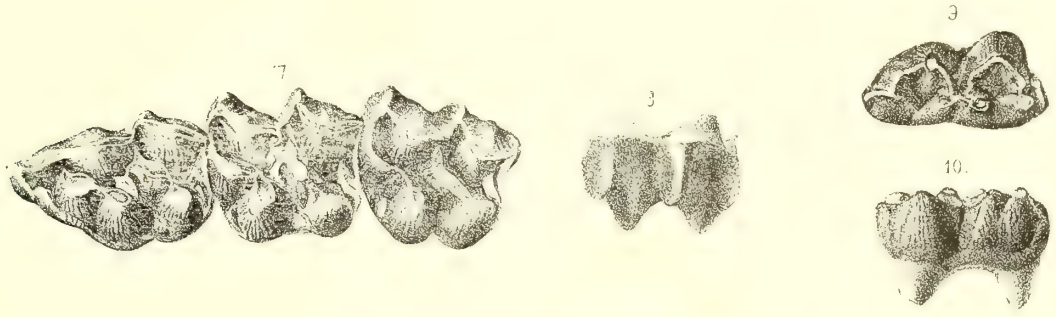

Fig. 71. Original figure of type of *Parahippus cognatus* Leidy, U. S. Nat. Mus. 567 (cast Am. Mus. 10772), three upper milk molars of the left side, dp$^{2, 3, 4}$, also dp$_2$. Natural size. After Leidy, 1869, Pl. xxi, figs. 7–10.

Parahippus leonensis Sellards 1916.

Text Fig. 72.

Parahippus leonensis, sp. nov., Sellards, E. H. "Fossil Vertebrates from Florida: A New Miocene Fauna; New Pliocene Species; the Pleistocene Fauna," *Eighth Ann. Rept. Florida State Geol. Surv.*, 1916, pp. 83–87, Pl. 11, fig. 7, Pl. 13, figs. 2, 3.

Horizon and locality.— (Sellards, p. 82) "Early in November, 1915, the Geological Survey received notice through Mr. E. B. Epps of the discovery of fragments of vertebrate fossils from a well on the Griscom plantation about 15 miles north of Tallahassee (Sec. 32, T. 3, N., R. I. E.)...After passing through the surface materials which consist of coarse red, clayey sands, 15 or 20 feet in thickness, the well from which these fossils were obtained enters the gray phosphatic sands and clays characteristic of the Alum Bluff formation and terminates at the depth of about 60 feet in hard limestone, probably of the Chattahoochee formation. The vertebrate fossils are imbedded in the gray phosphatic sands and are believed to have come chiefly from a depth of from 25 to 50 feet."

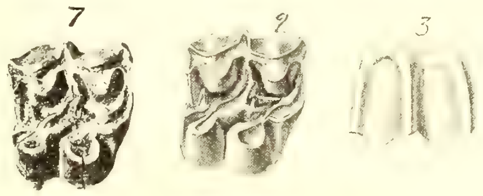

Fig. 72. Original figures of the type of *Parahippus leonensis* Sellards, right upper cheek tooth, probably m^1, Fla. Surv. Coll. 5084. Crown view, from photograph of the specimen, Pl. 11, fig. 7; drawings of the specimen Pl. 13, fig. 2 crown view, fig. 3 side view. All figures natural size. After Sellards, 1916.

Type.— Fla. State Geol. Surv. Coll. 5084. (Sellards, p. 83) "Among the fossils from the Griscom plantation is a horse represented by a permanent tooth from the right upper jaw, probably M^1, two lower cheek teeth, an astragalus and a first median and a first lateral phalanx. This horse is referred to the genus *Parahippus* and to the new species *P. leonensis*. A horse, probably the same species, is represented in the collection from the fuller's earth mine at Midway by a right astragalus, a second phalanx, a proximal part of a metacarpal, and a fragment of a tooth. The tooth from the upper jaw, Florida Survey collection No. 5084, is selected as the type of the species." Measurements: (Sellards, p. 83).

"Anteroposterior diameter of tooth, probably m^1	16 mm.
Transverse diameter, at base	19 mm.
Transverse diameter from summit median ridge to inner margin	15 mm.
Height of crown, tooth but slightly worn	13.5 mm."

Type figure.— Text Fig. 72 of this Memoir.

Characters.— (Sellards, pp. 83–85) "The tooth selected as the type is but little worn and serves well to show the characters of the species.... Of the described species of *Parahippus* this species presents apparently a rather close resemblance to *Parahippus* (*Anchippus*) *texanus* (Leidy).[1] From that species, however, it differs first of all in size, the anteroposterior diameter of the tooth being 16 mm. while that of the Texas species according to Gidley is 19 mm."

(?) PROCAMELUS-HIPPARION ZONE.

The following species is attributed to the Madison Valley formation of Montana (Douglass, 1899).

Parahippus minimus Douglass 1899.

Text Fig. 72a.

A[n]chitherium minimus, n. sp., Douglass, Earl. "The Neocene Lake Beds of Western Montana and Descriptions of Some New Vertebrates from the Loup Fork," Thesis for Degree of M.S., published by the University of Montana, June, 1899, pp. 26–27, no figure.

Horizon and locality.— (Douglass) "Both the above specimens were found in the Loup Fork formation in the lower Madison valley, western Montana." Collected by Earl Douglass, 1895. Douglass (letter Oct. 20, 1917) confirms the finding of this type in the Madison Valley formation (Lower Pliocene).

Type and paratype. Carnegie Mus. Nos. 713, 713a, 714. (Douglass, 1899, p. 26) "...two specimens consisting of the five upper posterior cheek teeth [type, Carnegie Mus. 713, paratype, 713a] and a mandibular ramus [paratype, Carnegie Mus. 714] of another individual. The jaw fragment contains the symphysis and the incisors, some of which are broken. I refer both of these fragments to the same species, as they correspond in size, and there is no reason to believe that they belong to separate species." Measurements: length of upper posterior five cheek teeth .067, length of upper molar series .0415, length of mandible to m_3 .111. Full measurements are given by Douglass, *op. cit.* pp. 26, 27.

(Osborn, 1918) The type superior molars were regarded by Douglass as a successive series of five teeth, p^3–m^3, belonging to one individual. They are regarded by Matthew (1917) as belonging to two individuals, namely, three teeth, p^3–m^1, constituting the type (Carnegie Mus. 713), and two teeth, a molar and a premolar (one of which has been misplaced), belonging to a larger animal (Carnegie Mus. 713*a*).

Type figure.— Text Fig. 72a of this Memoir.

Characters.— (Douglass, 1899, pp. 26, 27) *Type.* (1) I use *Anchitherium* in the restricted sense in which Scott has used it, the Madison species thus being, so far as I know, the second found in America. (2) It is much smaller than *A. aurelianense* Cuv. or *A. equinum* Scott. It differs from *A. equinum* in the following respects: (3) in p^3 cross crests united by an isthmus across the median valley, thus forming two enamel lakes, as in modern horses; in p^4 protoloph does not reach outer wall of crown; (5) posterior pillar proportionately larger than in Scott's specimen; (6) a small pillar at the entrance of the median valley in p^3; (7) in m^1 median transverse cross crest more sigmoid than in *A. equinum;* (8) posterior pillar connected with hypocone, with a single enamel loup extending outward; (9) outer crescents with rather faint median ridges. *Paratype lower jaw:* (1) incisors nearly uniform in size, semi-procumbent; (2) no diastema between incisors and canine; (3) post-canine diastema much longer than in *A. equinum;* (4) symphysis very long.

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[1] "Extinct Mammalian Fauna of Dakota and Nebraska," *Jour. Acad. Nat. Sci. Phila.* (2) Vol. VII, 1869, pp. 312–313, pl. XXI, fig. 13.

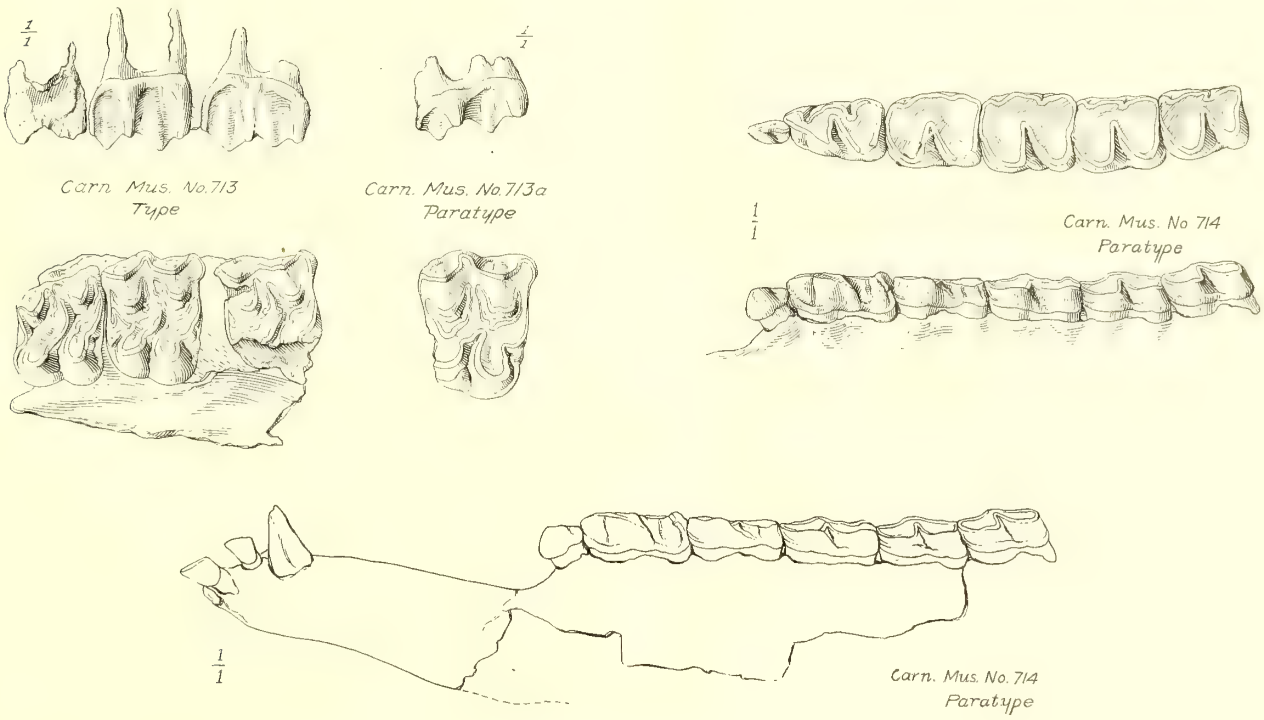

Fig. 72a. Type and paratypes of *Parahippus minimus* Douglass. Type Carnegie Mus. 713, paratypes 713a, 714. All figures natural size.

Reference. The type is in the dental stage of *Miohippus.* The premolars and molars are more primitive than those of *Archæohippus* or *Parahippus.* Although recorded from the Madison Valley Lower Pliocene, it may be a case of redeposition from underlying Oligocene.

GENUS **MERYCHIPPUS** Leidy 1857.

Proc. Acad. Nat. Sci. Phila. (1856) 1857, p. 311.

Genotype.— *Merychippus insignis* Leidy, see page 122, from the middle Upper Miocene of Bijou Hills, Brule County, South Dakota.

The types of the twenty-five species referred to this stage of equine evolution are widely distributed geographically and first appear geologically in the Middle Miocene of the Mascall, Oregon, and of the Deep River, Montana, in the Sheep Creek, western Nebraska, the lower Monolith Series, Tehachapi, California, the Virgin Valley, Nevada, and the Pawnee Creek, northeastern Colorado. There are late stages of *Parahippus* evolution, some of which (*P. brevidens*) are transitional to *Merychippus*. The *Merychippus* stage persists through the upper Middle Miocene into the Lower Pliocene and even into the supposed Lower Pliocene of Snake Creek where progressive stages of *Merychippus* (*M. calamarius, M. proparvulus, M. republicanus, M. patruus*) anticipate species of the *Protohippus, Pliohippus,* and *Hipparion* stages.

This generic stage includes many stages of progressive evolution in the *genesis and development of single characters,* such as the *crochet, hypostyle, plications of metaloph, preorbital fossæ,* also many advancing stages of *proportional evolution,* such as the elongation of the facial region, elongation of the limbs, reduction of the lateral digits, and especially the elongation, or hypsodontism, of the grinding teeth. This "single character" and "proportional character" evolution is complicated by the presence within the so-called genus *Merychippus* of several distinct phyletic series, some of which lead toward the *Protohippus* stage, others toward *Pliohippus,* others toward *Hipparion,* as observed by Matthew and the author, making *Merychippus* one of the most complex groups of distinct evolutionary phyla at present included within the confines of a single genus. It may well be split up in future into several subgenera when these phyla can be clearly and sharply distinguished from each other throughout the entire geologic period of its occurrence; but such splitting up is inadvisable until a very large number of "species," which are contemporaneous in the respective geologic levels and doubtless largely synonymous, can be either merged into each other or clearly distinguished.

The prevailing characters of this comprehensive genus are as follows:

1. Facial region exceeding cranial region, premolar series exceeding molar series.
2. Grinding teeth subhypsodont (*Parahippus brevidens*) to strongly hypsodont (*Merychippus calamarius*), upper grinders always strongly curved but molars less than premolars.
3. Grinding teeth assuming the crown pattern of *Equus,* (a) by the crescentic enlargement of the proto- and metaconules, (b) by the reduction and partial separation of the proto- and hypocones, (c) by the forward extension and branching of the crochet and hypostyle, and (d) by the plication of the enamel walls of the metaloph.
4. Superior and inferior milk molars brachyodont.
5. Protocone round or oval, closely united with protoloph or nearly separated to base.
6. Pre- and postfossettes completely enclosed, enamel fossette borders with simple or double plications.
7. In inferior grinders metastylid well separated from metaconid except near base of crown, where it fuses.
8. Antero-external cingulum flat, moderately prominent at base, ending abruptly about half way up the crown.
9. Lachrymal fossa deep or shallow, malar fossa shallow or absent.
10. Feet anisotridactyl, lateral digits abbreviated.

The grouping and phyletic succession of the species of *Merychippus* are not at all clear. The following lines of specific succession were suggested by Matthew in 1913.

Sheep Creek	*Mascall*	*Pawnee Creek*	*Republican River, Bijou Hills, Niobrara River,*
M. isonesus primus	*M. seversus*	*M. sphenodus*	?*M. insignis*
	" *isonesus*	" *paniensis*	? " *calamarius*
		" *campestris*	*Pliohippus mirabilis*
		" *proparvulus*	*Protohippus parvulus*
		" *eohipparion*	*Hipparion occidentale*
		" *sejunctus*	*Protohippus perditus*

I. TYPE DESCRIPTIONS OF THE SPECIES OF MERYCHIPPUS IN CHRONOLOGIC ORDER.

Date	Original name and author	Present reference	Locality	Life zone
1857	*Merychippus insignis* Leidy	*Merychippus insignis*	Bijou Hills, So. Dak.	?Procamelus-Hipparion zone
1874.1	*Hippotherium paniense* Cope	“ *paniensis*	Pawnee Buttes, northeastern Col.	Ticholeptus-Merychippus “
1874.2	*Protohippus labrosus* Cope	“ *labrosus*	“ “ “ “	“ “ “
1874.3	“ *sejunctus* Cope	“ *sejunctus*	“ “ “ “	“ “ “
1875	*Hippotherium calamarium* Cope	“ *calamarius*	New Mexico	Procamelus-Hipparion “
1878	*Stylonus seversus* Cope	“ *seversus*	Cottonwood Creek, Ore.	Ticholeptus-Merychippus “
1889.1	*Hippotherium relictum* Cope	“ *relictus*	Eastern Oregon	Zone undetermined
1889.2	“ *sphenodus* Cope	“ *sphenodus*	Pawnee Buttes, northeastern Col.	Ticholeptus-Merychippus zone
1889.3	“ *isonesum* Cope	“ *isonesus*	Cottonwood Creek, Ore.	Ticholeptus zone
1907	*Merychippus campestris* Gidley	“ *campestris*	Pawnee Buttes, northeastern Col.	Ticholeptus-Merychippus zone
1908	“ ?*missouriensis* Douglass	“ *missouriensis*	Confederate Creek, Winston, Mont.	?Ticholeptus “ “
1915.1	“ *californicus* Merriam	“ *californicus*	North Coalinga, Fresno Co., Cal.	Procamelus-Hipparion “
1915.2	“ *sumani* Merriam	“ *sumani*	Mohave Desert, Cal.	Upper Merychippus zone
1915.3	“ *intermontanus* Merriam	“ *intermontanus*	“ “ “	“ “ “
1915.4	“ *stylodus* Merriam (*nomen nudum*, = *M. calamarius*).			
1916	“ sp. Sellards	“ sp.	Near Quincy, Fla.	?
1918.1	“ *isonesus primus* Osborn	“ *isonesus primus*	Sheep Creek, western Nebr.	Ticholeptus-Merychippus zone
1918.2	“ “ *secundus* Osborn	“ “ *secundus*	“ “ “ “	“ “ “
1918.3	“ “ *tertius* Osborn	“ “ *tertius*	“ “ “ “	“ “ “
1918.4	“ “ *quartus* Osborn	“ “ *quartus*	“ “ “ “	“ “ “
1918.5	“ “ *quintus* Osborn	“ “ *quintus*	“ “ “ “	“ “ “
1918.6	“ *eoplacidus* Osborn	“ *eoplacidus*	Pawnee Buttes, northeastern Col.	“ “ “
1918.7	“ *proparvulus* Osborn	“ *proparvulus*	“ “ “ “	“ “ “
1918.8	“ *eohipparion* Osborn	“ *eohipparion*	“ “ “ “	“ “ “
1918.9	“ *republicanus* Osborn	“ *republicanus*	Driftwood Creek, western Nebr.	Pliauchenia-Peraceras “
1918.10	“ *patruus* Osborn	“ *patruus*	“ “ “ “	“ “ “

II. TYPES AS RECORDED OR INFERRED IN 1917 IN GEOLOGIC SUCCESSION.

Date	Species, Present reference	Life zone	Formation, Beds	Locality	Age
1918.10	*Merychippus patruus* Osborn	Pliauchenia-Peraceras zone	Republican River formation	Driftwood Creek, Western Nebraska	Lower Pliocene
1918.9	“ *republicanus* Osborn	“ “ “	“ “ “	“ “ “ “	“ “
1915.4	“ *stylodus* Merriam = *M. calamarius*				
1875	“ *calamarius* Cope	Procamelus-Hipparion “	Santa Fé marls	New Mexico	Upper Miocene or Lower Pliocene
1857	“ *insignis* Leidy	?Procamelus- “ “	Bijou Hills, So. Dak.	Bijou Hills (Brule Co., So. Dak.)	“ “
1915.1	“ *californicus* Merriam	Procamelus- “ “	“Temblor” formation	North Coalinga, Fresno Co., Cal.	Upper “ “ “ “
1915.3	“ *intermontanus* Merriam	Upper Merychippus “	Barstow “	Mohave Desert, Cal.	Upper Miocene
1915.2	“ *sumani* Merriam	“ “ “	“ “	“ “ “	“ “
1908	“ *missouriensis* Douglass	?Ticholeptus-Merychippus zone	Confederate Creek, Winston, Mont.	Confederate Creek, Winston, Mont.	?Middle Miocene
1918.8	“ *eohipparion* Osborn	Ticholeptus-Merychippus “	Pawnee Creek formation	Pawnee Buttes, northeastern Colorado	Middle Miocene (middle levels)
1918.7	“ *proparvulus* Osborn	“ “ “	“ “ “	“ “ “ “	“ “ “ “
1918.6	“ *eoplacidus* Osborn	“ “ “	“ “ “	“ “ “ “	“ “ “ “
1907	“ *campestris* Cope	“ “ “	“ “ “	“ “ “ “	“ “ “ “
1889.2	“ *sphenodus* Cope	“ “ “	“ “ “	“ “ “ “	“ “ “ “
1874.3	“ *sejunctus* Cope	“ “ “	“ “ “	“ “ “ “	“ “ “ “
1874.2	“ *labrosus* Cope	“ “ “	“ “ “	“ “ “ “	“ “ “ “
1874.1	“ *paniensis* Cope	“ “ “	“ “ “	“ “ “ “	“ “ “ “
1918.5	“ *isonesus quintus* Osborn	“ “ “	Sheep Creek beds (Arikaree)	Sheep Creek, western Nebraska	Middle Miocene (lower levels)
1918.4	“ “ *quartus* Osborn	“ “ “	“ “ “ “	“ “ “ “	“ “ “ “
1918.3	“ “ *tertius* Osborn	“ “ “	“ “ “ “	“ “ “ “	“ “ “ “
1918.2	“ “ *secundus* Osborn	“ “ “	“ “ “ “	“ “ “ “	“ “ “ “
1918.1	“ “ *primus* Osborn	“ “ “	“ “ “ “	“ “ “ “	“ “ “ “
1889.3	“ “ Cope	“ “ “	Mascall formation	Cottonwood Creek, Ore.	“ “
1878	“ *seversus* Cope	“ “ “	“ “	“ “ “	“ “
1916	“ sp. Sellards	?	?	Near Quincy, Fla.	?Lower Middle Miocene
1889.1	“ *relictus* Cope	Zone undetermined	?Silver Lake, ?Mascall formation	Eastern Oregon	Lower or Middle Miocene

All the evolutionary stages in the crown pattern of the grinding teeth of *Merychippus* may be followed in Plates 11 to 20, from the lower Middle Miocene of Sheep Creek (*M. isonesus primus*) through the Middle Miocene into the Upper Miocene or Lower Pliocene (*M. calamarius, M. republicanus*). The key to this crown pattern is presented in Figs. 2, 3.

TICHOLEPTUS-MERYCHIPPUS ZONE. 9. MIDDLE MIOCENE.

This zone is typified in the Mascall of Oregon. It contains an abundant *Merychippus* fauna mingled with progressive species of *Parahippus*.

Merychippus relictus Cope 1889.

Plate 13.9, 17.2. Text Fig. 73.

Hippotherium relictum sp. nov., Cope, E. D. "An Intermediate Pliocene Fauna," *Amer. Naturalist*, Vol. XXIII, No. 268, Apr. 1889, pp. 253–254, no figure. "A Review of the North American Species of Hippotherium," *Proc. Amer. Philos. Soc.* Vol. XXVI, 1889 (sig. dated June 5, 1889), p. 449, figs. 19, 19a, 20.

Horizon and locality.— (Cope, *Am. Nat.* 1889, p. 253) "...a lake deposit in Oregon containing *Canis, Elephas* or *Mastodon, Holomeniscus* or *Auchenia, Aphelops, Equus.*" May be regarded as representing the Middle or Lower Pliocene. (Cope, 1889) "From a Lower Pliocene bed (? Idaho terrane) of the eastern part of Oregon." (Gidley, 1907, p. 906) "Horizon not known, but probably Middle or Lower Miocene." Type collected by George C. Duncan. (Matthew, 1915) Duncan's collection consisted in part of Pleistocene species, black, hard, resembling the Silver Lake material in preservation. The remainder is softer, light buff colored, and consists wholly of Miocene species. Merriam thinks the Miocene material may have come from out-lying beds of the Mascall. Possibly so, but my impression is that the rhinoceroses and camels are later than Mascall. There may be three horizons mixed, Mascall, Rattlesnake, Silver Lake."

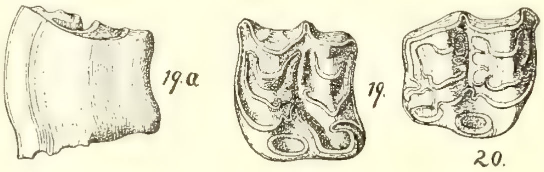

Fig. 73. Original figures of the type of *Merychippus relictus* Cope, Am. Mus. Cope Coll. 8673, ?m^1, ^{3}. Natural size. After Cope, 1889, figs. 19, 19*a*, 20.

Type.— Amer. Mus. Cope Coll. 8673. (Cope, *Am. Nat.* 1889, p. 254) "Represented by two superior and three inferior molar teeth." Measurements: (Gidley, 1907, p. 906) m^1 a. p. .016, tr. .018, height of crown .020 outside, .014 inside; m^3 a. p. .0165, tr. .0165, height of crown .016 outside, .012 inside.

Type figure.— Text Fig. 73 of this Memoir.

Characters.— (Cope, *Am. Nat.* 1889, p. 254, Osborn, 1918) (1) Grinding surface nearly square; (2) the partly worn crown relatively short, moderately curved; (3) section of internal style (protocone) a wide oval, disconnected with hypocone and hypostyle; (4) hypocone extending as far inward as protocone; (5) median branch of metaconule a posterior spur of protoconule, ptychoid, a pli caballin, abundant cement. (6) About the size of *Merychippus seversus* and resembling it in many details.

Merychippus seversus Cope 1878.

Plate 13.8, 17.1. Text Fig. 74.

Stylonus seversus, gen. et sp. nov., Cope, E. D. "On Some of the Characters of the Miocene Fauna of Oregon," *Proc. Amer. Philos. Soc.* Vol. XVIII, 1878–1880 (sig. dated Dec., 1878), p. 76, no figure. *Palæontological Bull.* No. 30, "Dec. 3, 1878." *Hippotherium seversum* Cope, "A Review of the North American Species of Hippotherium," *P. A. P. S.*, Vol. XXVI, June, 1889, pp. 457, 458, fig. 24, 24a.

Horizon and locality.— Mascall formation of Cottonwood Creek, Ticholeptus zone, Grant County, Oregon. Type collected by J. L. Wortman.

Type.— Am. Mus. 8180. (Cope, 1878, p. 76) "Two superior molar teeth were accompanied by a number of inferior molars as having been all found together, but whether they belong to one individual is uncertain." (1889) "... *H. seversum* was originally described from a superior molar, which though worn over the entire grinding face of the crown still retains the posterior column [hypocone] distinct from the posterior inner crescent." (Gidley, 1907, p. 897) "A right upper molar tooth, ?m^2, Amer. Mus. 8180." Measurements: (Gidley) m^2 a. p. .0175, tr. .0165, height of crown .028 outside, .016 inside.

Type figure.— Text Fig. 74 of this Memoir.

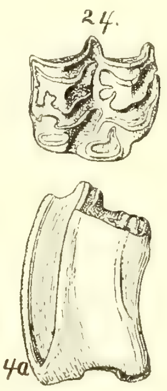

Fig. 74. Original figures of the superior molar of the type of *Merychippus seversus* Cope, Am. Mus. 8180. Natural size. After Cope, 1889, figs. 24, 24*a*.

Characters.— (Cope, 1889, p. 457, Osborn, 1918) (1) Crown of superior molar moderately elongate [hypsodont], curved; (2) section of anterointernal column [protocone] an elongate oval with an anterior spur directed toward the internal median group [protoconule]; (3) posterointernal column [hypocone] also elongate oval in section, distinct from posterointernal crescent [metaconule]; (4) crescents [protoconule and metaconule] separated by wide lakes [fossettes] entirely filled with cement; (5) borders of metaconule crescent ptychoid, protoconule crochet junction with pli caballin; (6) ectoloph without median paracone and metacone.

Among the referred specimens from the Mascall are Amer. Mus. 8181, 8182. It should be compared with *M. sphenodus,* from a somewhat later horizon, which it antedates.

Merychippus isonesus Cope 1889.

Plates 6.8, 10.4, 13.1,2, 17.3,4, 42.1,2. Text Figs. 75, 77.

Hippotherium isonesum Cope. "A Review of the North American Species of Hippotherium," *Proc. Amer. Philos. Soc.*, Vol. XXVI, 1889, (sig. dated June 5, 1889), pp. 451–457, fig. 23. This type was originally referred to as *Hippotherium seversum* Cope, Cope, E. D., [Named and listed] "On Two New Species of Three-toed Horses from the Upper Miocene, with Notes on the Fauna of the Ticholeptus Beds," *Proc. Amer. Philos. Soc.*, Vol. XXIII, April, 1886, p. 359. Not Vol. XVIII, 1878, p. 76.

Horizon and locality.— Mascall formation of the John Day series, Cottonwood Creek, Oregon, Ticholeptus zone. Type collected by J. L. Wortman.

Type.— Amer. Mus. Cope Coll. 8175. A nearly complete skull, cervical vertebræ, pelvis and hind limbs. Measurements: (Cope, 1889, p. 453) incisors to occipital condyles .328; m^1 a. p. .019, tr. .019; length of Mts. III .175.

Type figure.— Text Fig. 75 of this Memoir.

Characters.— (Gidley, 1907, p. 909, Osborn 1918) (1) Molars comparatively short-crowned, of true *Merychippus* type; (2) protocone and hypocone subequal in size, elongate-oval, with internal spurs approaching protoconule and metaconule respectively; (3) hypocone early joining metaconule; (4) protocone separated half way down the crown; (5) median crest of metaconule and crochet region ptychoid; (6) a pli caballin. (7) Facial region relatively short; (8) a single lachrymo-malar fossa, not well separated.

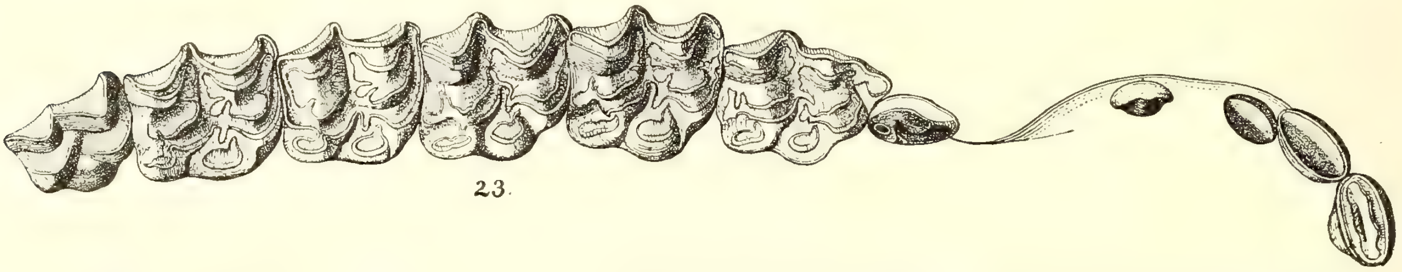

Fig. 75. Original figure of the teeth of the type of *Merychippus isonesus* Cope, Am. Mus. Cope Coll. 8175. Natural size. After Cope, 1889, fig. 23.

Matthew (1913) regards this type as rather close to that of *M. paniensis* with some valid specific differences. The median metapodials (Mts. III) and the laterals (Mts. II, IV) are less produced than in *M. paniensis.*

Merychippus isonesus primus mut. nov.

Plates 13.3, 14.2,4, 25.4, 39.2. Text Fig. 78.

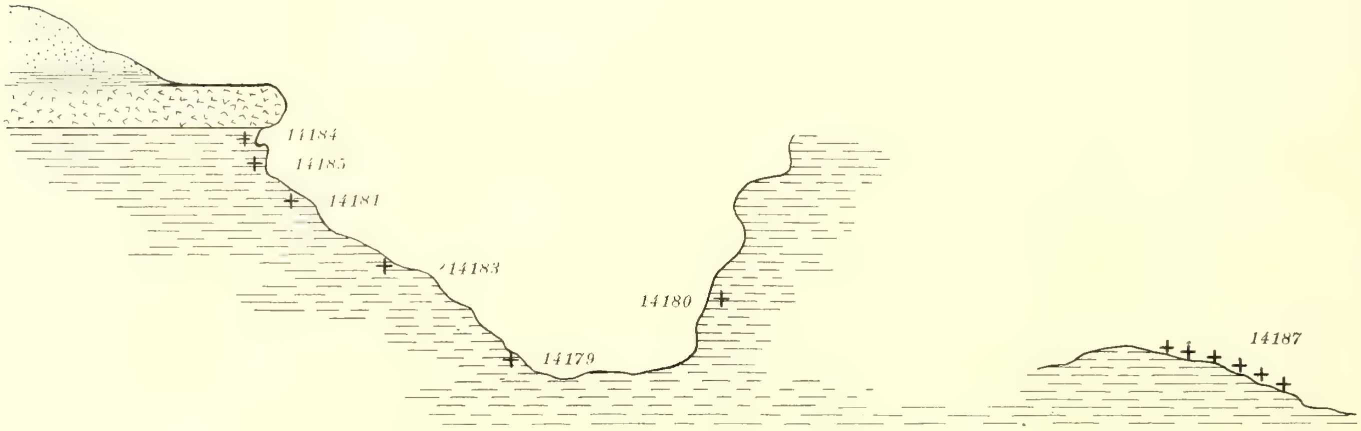

Fig. 76. Geologic distribution in ascending order of mutations of *Merychippus isonesus* from Sheep Creek.

Amer. Mus. 14184, type of *M. isonesus quartus* Osborn; Amer. Mus. 14185, type of *M. isonesus quintus* Osborn; Am. Mus. 14181, specimen referred to *M. isonesus quartus* Osborn; Am. Mus. 14180, type of *M. isonesus tertius* Osborn; Am. Mus. 14179, type of *M. isonesus secundus* Osborn; Am. Mus. 14187, type and topotype of *M. isonesus primus* Osborn, the most primitive form. The section represents one of the gullies in the Sheep Creek beds, at the type locality. Near the top of the Sheep Creek is a three-foot bed of grey volcanic ash. A little above are the unconsolidated sands of the Snake Creek horizon.

Horizon and locality.— Sheep Creek phase of Arikaree formation, western Nebraska, lower Middle Miocene. Type collected by American Museum Expedition of 1908.

Type.— Amer. Mus. 14187. Upper grinding teeth, p^2–m^3.

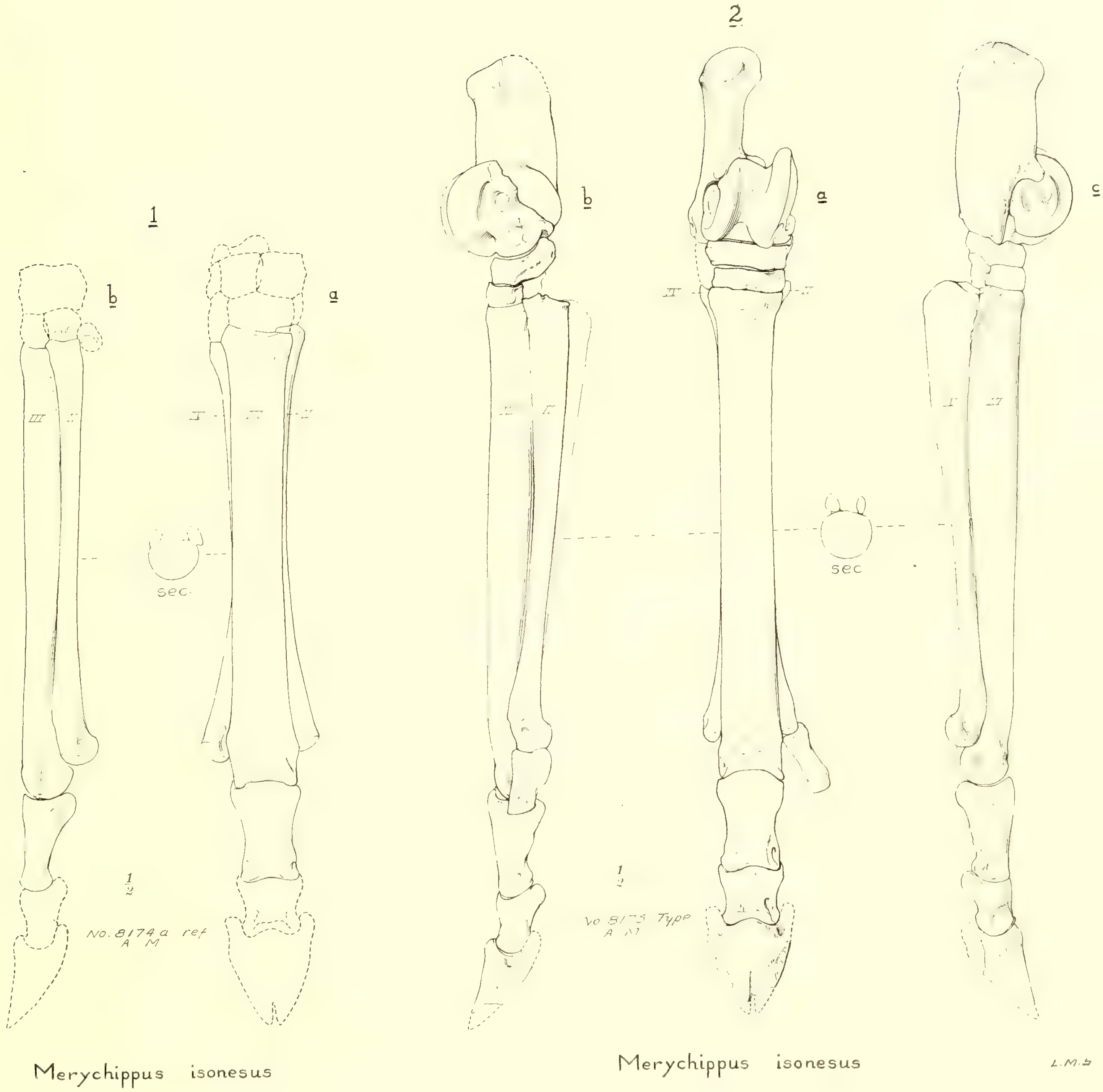

Fig. 77. *Merychippus isonesus* Cope. (Three right-hand figures) Amer. Mus. 8175, hind feet of the type, (a) anterior, (b) internal, and (c) external views, with section of metatarsals; (two left-hand figures) manus of Amer. Mus. 8174a, a referred specimen, (b) internal, and (a) anterior views, with section of metacarpals. All figures one-half natural size.

Topotypes.— Numerous fragments of upper and lower jaws, teeth, and skeletal material, mostly isolated, Amer. Mus. 14187, from the same locality.

Type figure.— Plates 13.3, 14.2,4, text Fig. 78 of this Memoir.

Characters.— (Matthew, 1913) (1) An animal of smaller size than the type of *M. isonesus secundus,* about equalling in size the type of *M. seversus.* (2) Crochet apparently single, *i. e.* no pli caballin, separate from protoloph except in well worn teeth; (3) protocone elongate transversely, strongly united with protoconule at an early stage of wear; (4) usually a single enamel fold projecting from metaloph into prefossette and a single fold projecting into postfossette. (5) Limb and foot bones slender.

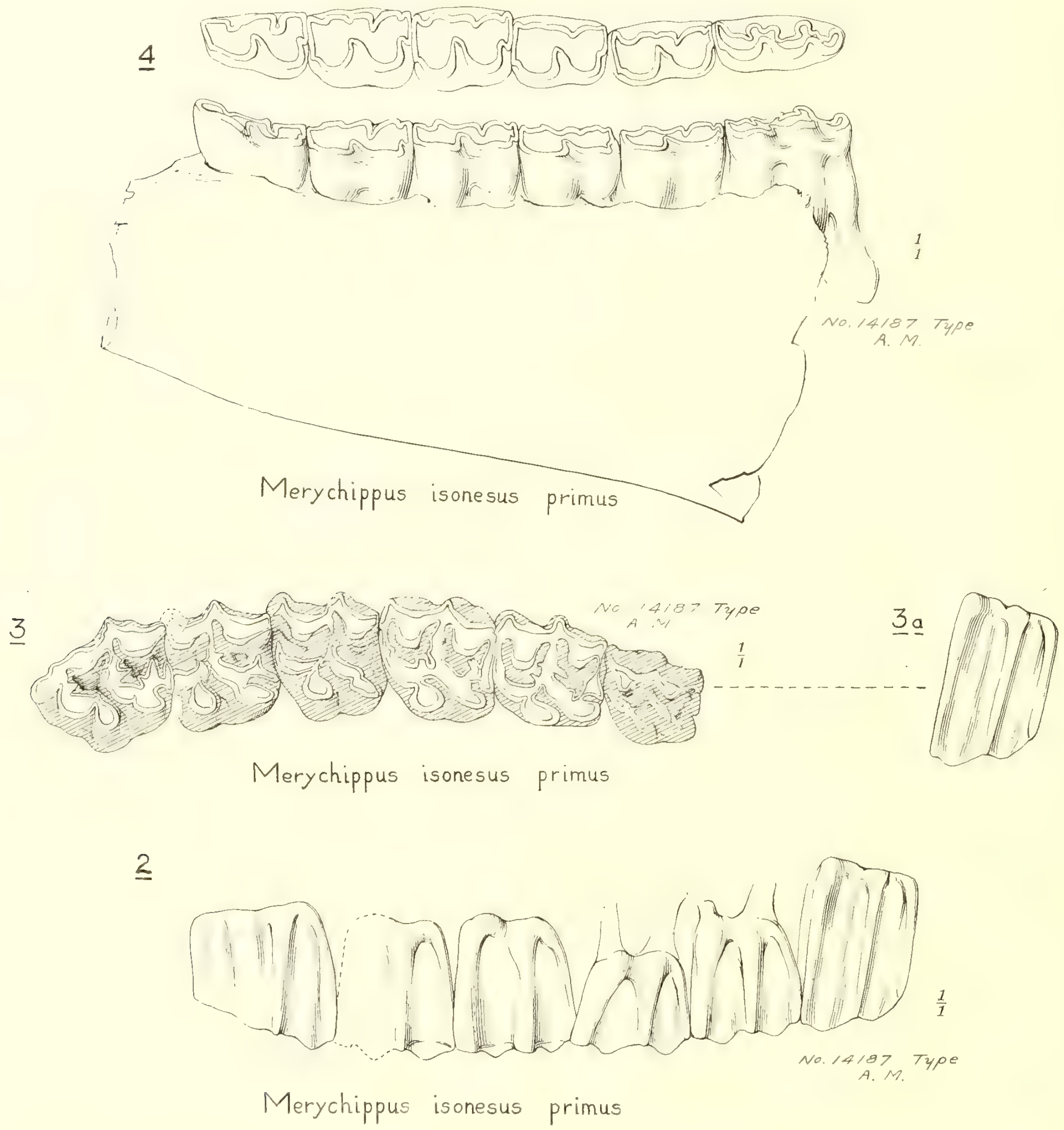
4
1/1
No. 14187 Type
A. M.
Merychippus isonesus primus
3
No. 14187 Type
A. M.
1/1
3a
Merychippus isonesus primus
2
1/1
No. 14187 Type
A. M.
Merychippus isonesus primus

Fig. 78. Type of *Merychippus isonesus primus* Osborn, Amer. Mus. 14187. Crown and side view of upper and lower dentition. All figures natural size.

The large number of topotypes from the same level agree very well with the type characters.

Merychippus isonesus secundus mut. nov.

Plates 13.4, 41.1, 45.1,3, 46.1, 52.1. Text Fig. 79.

Horizon and locality.— Sheep Creek phase of Arikaree formation, western Nebraska, lower Middle Miocene. Type collected by Harold J. Cook of American Museum Expedition of 1908.

Type.— Amer. Mus. 14179. Fragments of upper and lower jaws with most of the teeth and parts of skeleton.

Type figure.— Plates 13.4, 41.1, 45.1, 3, 46.1, 52.1, text Fig. 79 of this Memoir.

Characters.— (Matthew, 1913, Osborn, 1918) (1) Teeth the same size as *M. isonesus.* (2) Crochet forked instead of single as in *M. isonesus primus;* (3) not united to protoconule except in well worn teeth; (4) protocone bulbous, transversely expanded, united to protoconule in half worn teeth; (5) a beginning of the pli caballin, namely, lower branch of crochet; (6) two folds extending from metaloph into prefossette and two folds extending into postfossette; (7) hypostyle slightly plicate. (8) Shafts of limb bones slender; (9) metapodials long and slender, lateral digits considerably reduced; (10) Mts. III with strongly compressed shaft; (11) ulnar shaft closely compressed but not united with radius; (12) shafts of lateral digits and lateral phalanges much reduced.

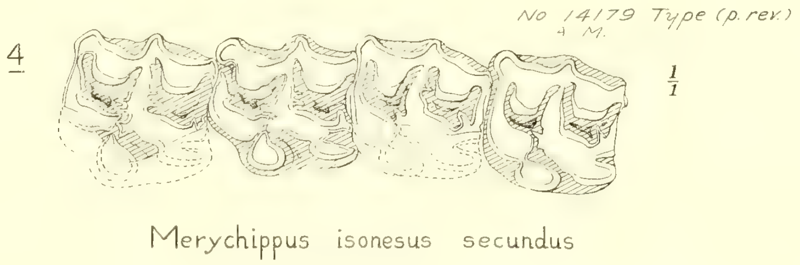

Fig. 79. *Merychippus isonesus secundus* Osborn, Amer. Mus. 14179, p^3–m^2 of the type, crown view. Partly reversed in drawing from right and left sides. Natural size.

Merychippus isonesus tertius mut. nov.

Plates 13.5,6, 14.3, 41.2, 46.2, 52.2. Text Fig. 80.

Horizon and locality.— Sheep Creek phase of Arikaree formation, western Nebraska, lower Middle Miocene. Type collected by Albert Thomson of American Museum Expedition of 1908.

Type.— Amer. Mus. 14180. Palate and complete series of grinding teeth, p^2–m^3, lower jaws and parts of skeleton.

Topotype.— Upper and lower jaws with well worn teeth, Amer. Mus. 14183.

Type figure.— Plates 13.5, 14.3, 41.2, 46.2, 52.2, text Fig. 80.

Characters.— (Matthew, 1913, Osborn, 1918) (1) This type is slightly larger than the preceding. (2) Crochet uniting with protoconule in half worn teeth, giving off a prominent internal fold, or pli caballin; (3) protocone a long oval, uniting by a strong interior spur with middle compression of protoconule crescent in half worn teeth; (4) prominent plications of the metaloph entering pre- and postfossettes; (5) rudiments of the second plication. (6) Limb bones as in *M. isonesus secundus,* but shafts more robust than in the preceding type; (7) shafts of lateral digits as in *M. isonesus secundus;* (8) ulna fused for a short distance with radius. This type is separable from *M. isonesus secundus* in the antero-posterior elongation of the protocone. It is a premutation which is closely united to the preceding but shows a slight advance in the pli caballin, in the early union of protoconule and crochet, and the somewhat greater anteroposterior elongation of the protocone. The referred specimen, Amer. Mus. 14183, a topotype, exhibits the manner in which all the enamel plications and folds disappear in much worn crowns.

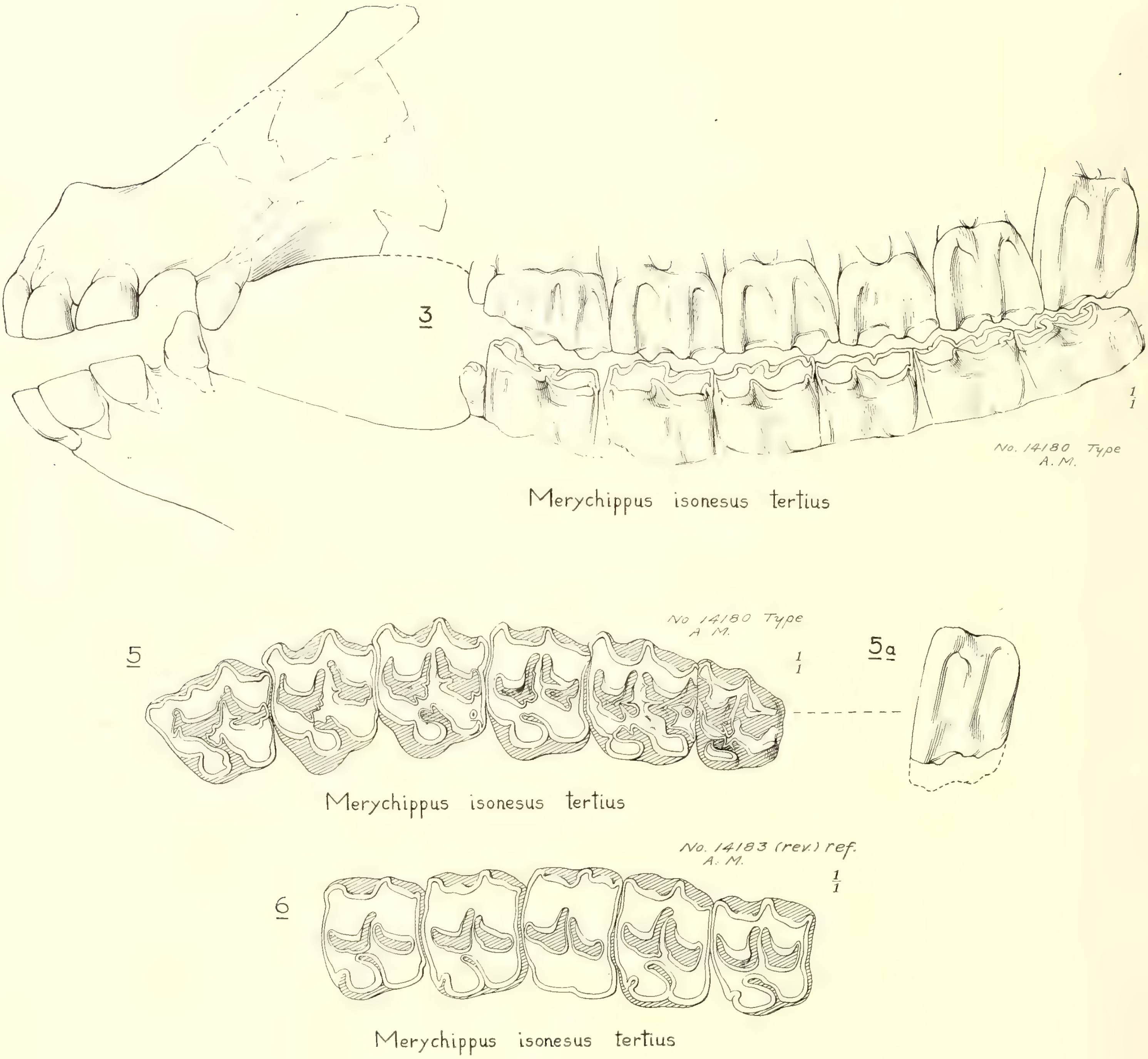
3
1/1
No. 14180 Type
A. M.
Merychippus isonesus tertius
5
No 14180 Type
A M.
1/1
5a
Merychippus isonesus tertius
No. 14183 (rev.) ref.
A. M.
6
1/1
Merychippus isonesus tertius

Fig. 80. *Merychippus isonesus tertius* Osborn. (3, 5, 5a) Amer. Mus. 14180, type. (3) Side view of upper and lower type dentition of the left side; (5) crown view of superior grinding teeth of type; (5a) external view of type m^3; (6) crown view of p^3–m^3 of referred specimen, Amer. Mus. 14183, reversed in drawing. All figures natural size.

Merychippus isonesus quartus mut. nov.

Plates 41.3, 45.4, 46.3, 52.3.

Horizon and locality.— Sheep Creek phase of Arikaree formation, western Nebraska, lower Middle Miocene. Type collected by W. D. Matthew of American Museum expedition of 1908.

Type.— Amer. Mus. 14184. Part of skeleton without skull parts or teeth.

Type figure.— Plates 41.3, 45.4, 46.3, 52.3.

Characters.— (1) Limb bones as long as in *M. isonesus quintus* but decidedly more slender; (2) shafts of limb bones of same weight as in *M. isonesus tertius* but considerably more elongate; (3) metapodials of same length as in *M. isonesus quintus* but smaller at distal ends; (4) shafts of lateral digits and the lateral phalanges much as in *M. isonesus secundus.*

An intermediate premutation stage is indicated by this type. The limb bones indicate, however, that it is to be regarded at present as a definable type.

Merychippus isonesus quintus mut. nov.

Plates 13.7,7a, 14.1, 41.4, 45.2,5, 46.4. Text Fig. 81.

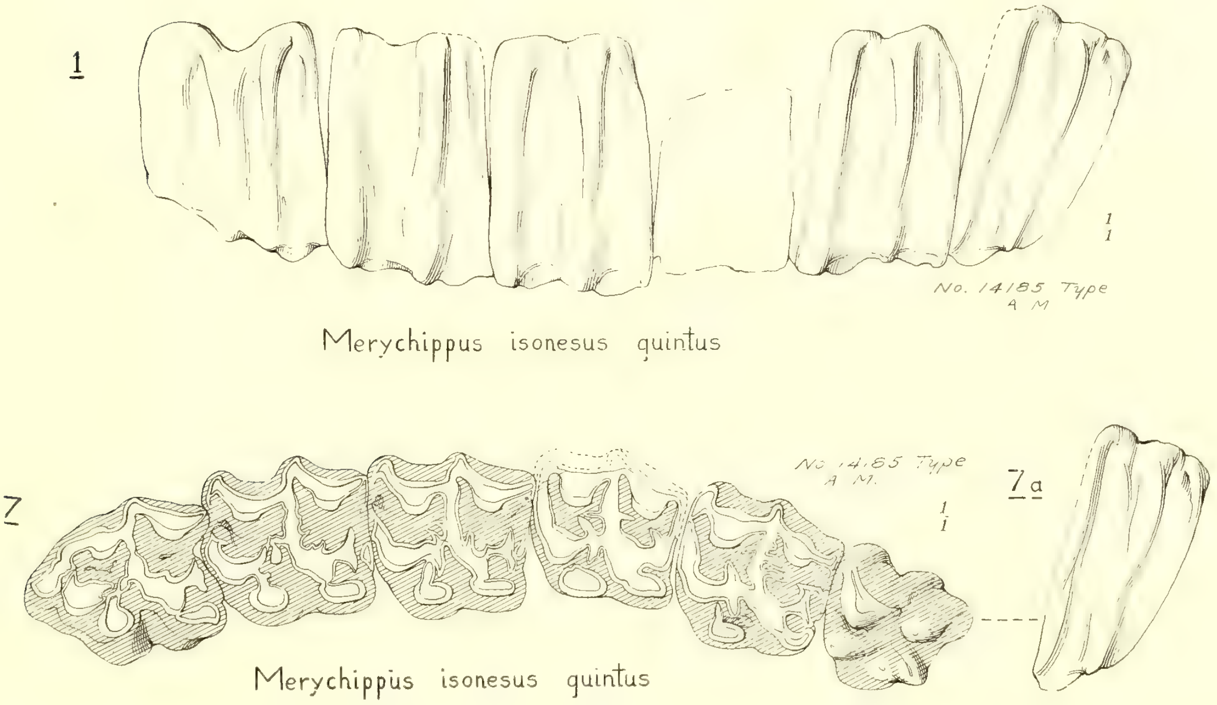

Fig. 81. *Merychippus isonesus quintus* Osborn, Amer. Mus. 14185. (1) Side view of left premolar-molar series of the type; (7) crown view of same; (*7a*) side view of m^3 of the type. All figures natural size.

Horizon and locality.— Sheep Creek phase of Arikaree formation, western Nebraska, lower Middle Miocene. Type collected by W. D. Matthew of American Museum Expedition of 1908.

Type.— Amer. Mus. 14185. Upper and lower dentition and a large part of a skeleton.

Type figure.— Plates 13.7,7a, 14.1, 41.4, 45.2,5, 46.4, text Fig. 81 of this Memoir.

Characters.— (Matthew, 1913, Osborn, 1918) (1) The type a larger animal than any of the preceding premutations, approaching *M. seversus* in the plications of the enamel; (2) crochet bifid, *i. e.* with a large spur projecting into the prefossette and a large inferior pli caballin fold; (3) protocone separate from protoconule in little worn molars, uniting with protoconule in molars one-fourth worn; (4) protocone elongate anteroposteriorly in p^4–m^3; (5) metaloph sending a single fold into prefossette, and from one to two folds into postfossette; (6) shafts of limbs robust; (7) metapodials robust; (8) shafts of lateral digits and lateral phalanges much heavier than in *M. isonesus secundus* and *M. isonesus tertius.*

Merychippus sp. Sellards 1916.

Text Fig. 82.

Merychippus sp., Sellards, E. H. "Fossil Vertebrates from Florida: A New Miocene Fauna; New Pliocene Species; The Pleistocene Fauna," *Eighth Ann. Rept. Florida State Geol. Surv.*, 1916, pp. 87–88, Pl. 11, fig. 1, Pl. 13, fig. 6.

Horizon and locality.— (Sellards, pp. 87–88) "In 1908 the writer obtained from the fuller's earth mine at Quincy a single lower cheek tooth of *Merychippus.* The specimen was secured from a workman who found it while digging with a pick in the indurated sand above the fuller's earth stratum. Further evidence of its place in the deposit is afforded by the fact that the base of the tooth contained the gray sand characteristic of the Alum Bluff formation."

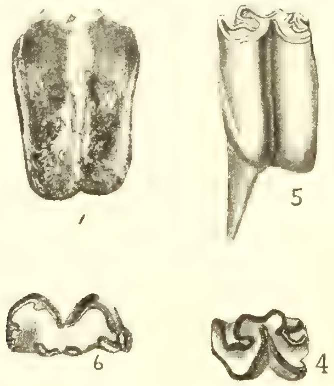

Fig. 82. *Merychippus* sp. Sellards. (Left figures) Fla. Surv. Coll. 173, type, lower cheek tooth; (upper) side view from photograph, Pl. 11, fig. 1, (lower) crown view, drawing, Pl. 13, fig. 6. (Right figures) Fla. Surv. Coll. 7527, lower cheek tooth, a referred specimen; (upper) side view, Pl. 13, fig. 5, (lower) crown view, Pl. 13, fig. 4. All figures natural size. After Sellards, 1916.

Type.— (Sellards, p. 88) "The specimen is No. 173 of the Florida Survey collection . . . The species is no doubt new although it is desirable to secure additional material to serve as a type before naming the species." Measurements: (Sellards, p. 88) "Greatest anteroposterior length, 17 mm.; width 7 mm."

Type figure.— Text Fig. 82 of this Memoir.

Characters.— (Sellards, p. 88) "The tooth, as may be seen by the illustrations, is moderately hypsodont and has a coating of cement. The metaconid and metastylid are distinctly separated. The tooth is but little worn and may be referred with confidence to the genus *Merychippus.* Professor J. C. Merriam, who has compared this tooth with the horses of the western United States contained in the University of California collection, has kindly supplied the following notes:

> 'Your tooth, No. 173, most closely approaches the lower dentition of one of our horses from the recently discovered fauna occurring in beds crossing the summit of the Southern Sierra of Tehachapi. One of these species I have considered the most primitive known *Merychippus*. . . . I will say in conclusion that your specimen No. 173, is very much more progressive than any Oligocene horse known to me. It is certainly very different from our uppermost John Day horses. Your specimen is also more progressive than any horse certainly referred to the lower Miocene of North America. Our fauna from the Tehachapi is presumably middle Miocene, but it might possibly be the uppermost portion of the lower Miocene. I should judge that the horizon from which tooth No. 173 came is somewhere near the lower portion of the middle Miocene, unless there is a very unusually advanced type in an old formation or an unusual survival of an old form in a late formation.'"

MERYCHIPPUS PANIENSIS-M. SEJUNCTUS ZONE. 10. LATE MIDDLE MIOCENE.

This zone is typified at Pawnee Creek, Colorado, and contains numerous species of *Merychippus.*

Merychippus paniensis Cope 1874.

Plates 11.2, 16.4,5,6, 18.1,5, 25.5, 34.1,2, 43.2, 48.2, 50.2,6, 53.2. Text Fig. 83.

Hippotherium paniense, sp. nov., Cope, E. D. "Report on the Stratigraphy and Pliocene Vertebrate Paleontology of Northern Colorado," *Bull. U. S. Geol. and Geog. Surv. Terr.*, Vol. I, No. 1, Jan. 21, (1873) 1874, p. 12, no figure. Same description included in "Report on the Vertebrate Paleontology of Colorado," *Ann. Rept. U. S. Geol. and Geog. Surv. Terr.*, 1874, p. 522, no figure. "A Review of the North American Species of Hippotherium," *Proc. Amer. Phil. Soc.*, Vol. XXVI, 1889 (sig. dated June 5, 1889), pp. 447–448, figs. 13a–14.

Horizon and locality.— Pawnee Creek formation, Pawnee Buttes, northeastern Colorado, Merychippus zone, Middle Miocene. Type collected by Edward D. Cope.

Type.— Amer. Mus. Cope Coll. 8249. A right upper molar, m^1. Measurements: (Gidley, 1907, p. 890) m^1 a.p. .0185, tr. .020, height of crown outside .026, inside .0115. *Cotype.* A left upper molar, m^3, Amer. Mus. Cope Coll. 8250. Measurements: (Gidley, *op. cit.*) m^3 a.p. .020, tr. .0185, height of crown outside .030, inside .016.

Type figure.— Text Fig. 83 of this Memoir.

Characters.— (Cope, 1874, Osborn, 1918) (1) Enamel borders of hypostyle, of metaloph, and crochet region ptychoid; (2) protocone separate in incompletely worn crown; (3) marked curvature of the crown; (4) crown of intermediate length, hypsodont. Cope considered this animal an hipparion. Gidley (1907) considered the species not well characterized. Matthew (1913) refers to it a number of characteristic specimens from the Pawnee Creek formation, namely, parts of skull and jaws, fore and hind limbs and feet, Amer. Mus. 9382; also Amer. Mus. 9039, 9093, 9413, 9460, and adds the following characters (1913): (1) size median, same as *M. sejunctus;* (2) hypsodonty as in *M. sejunctus;* (3) protocone separate to near base or united half way up crown; (4) protocone typically small, round-oval; (5) pli caballin fold well developed; (6) lachrymal fossa deep, abrupt, commencing close to border of orbit; (7) limbs relatively shorter than in *M. sejunctus*, lateral digits more robust; (8) ungual phalanges short and narrow. Matthew (1913) regards it as close to *M. isonesus* of the Mascall but somewhat more progressive.

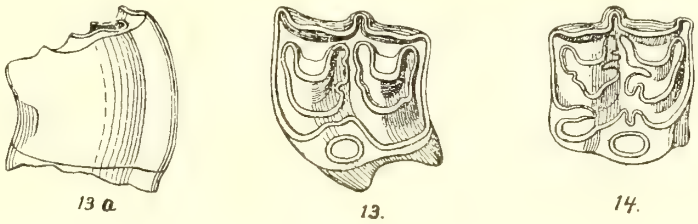

Fig. 83. Original figures of the type of *Merychippus paniensis* Cope, Am. Mus. Cope Coll. 8249, a right upper molar, m^1. Natural size. After Cope, 1889, figs. 13a–14.

Referred specimens are, Amer. Mus. 8255, 8290, 9382, 9403, 9413.

Merychippus labrosus Cope 1874.

Text Fig. 84.

Protohippus labrosus sp. nov., Cope, E. D. "Report on the stratigraphy and Pliocene Vertebrate Paleontology of Northern Colorado," *Bull. U. S. Geol. and Geog. Surv. Terr.*, Vol. I, No. 1, Jan. 21, (1873) 1874, p. 13, no figure. Same description included in "Report on the Vertebrate Paleontology of Colorado," *Ann. Rept. U. S. Geol. and Geog. Surv. Terr.*, 1874, p. 523, no figure.

Horizon and locality.— Pawnee Buttes, Pawnee Creek formation, Merychippus zone, Middle Miocene of northeastern Colorado. Type collected by Edward D. Cope.

Type.— Amer. Mus. Cope Coll. 8266. A mandible. (Cope) "The specimen of *P. labrosus* embraces also the right maxillary bone, containing five molars; a second specimen [*paratype*] includes three superior molars of the left side; it is also represented by several isolated molars." The type, Amer. Mus. 8266, consists primarily of the "mandible," which is, in fact, a composite of two jaw fragments, the symphysis and the (right) ramus belonging certainly to different individuals and probably to distinct species. The symphysis is evidently the primary type. The "right maxillary bone" has not been located. Measurements: p^2 a.p. .022, tr. .019; m^1 a.p. .018, tr. .022.

Type figure.— Text Fig. 84 of this Memoir.

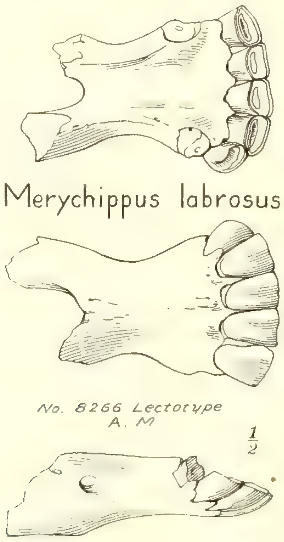

Fig. 84. *Merychippus labrosus* Cope, lectotype, Amer. Mus. Cope Coll. 8266. Mandibular symphysis and incisors One-half natural size.

Merychippus sejunctus Cope 1874.

Plates 11.1, 16.1,2,3, 19.1,2, 20,43.3, 48.1, 50.1,5, 53.3. Text Figs. 85, 85a, 86.

Protohippus sejunctus, sp. nov., Cope, E. D. "Report on the stratigraphy and Pliocene Vertebrate Paleontology of Northern Colorado," *Bull. U. S. Geol. and Geog. Surv. Terr.*, Vol. I, No. 1, Jan. 21 (1873), 1874, p. 15, no figure. Same description included in "Report on the Vertebrate Paleontology of Colorado," *Ann. Rept. U. S. Geol. and Geog. Surv. Terr.* (1873) 1874, p. 524, no figure. "On the Origin of the Foot Structures of the Ungulates." *The Amer. Naturalist*, Vol. XV, No. 4, April, 1881, p. 271, fig. 3.[1]

Horizon and locality.— Pawnee Buttes, Pawnee Creek formation, northeastern Colorado, Middle Miocene, Merychippus zone. Type collected by Edward D. Cope.

Type and paratypes.— Amer. Mus. Cope Coll. 8291. (Cope) "Represented in my collections by a nearly complete skeleton, with cranium and entire dentition, both mandibular rami and symphysis of a second; mandibles and dentition of two others, with appropriate molar teeth." *Type.* "Complete skull and lower jaws with entire dentition and parts of the skeleton associated, including the hind feet. Measurements: (Cope) "Length of entire molar series .124." (Gidley, 1907, p. 892) Total length of skull taken on basal line .325; p^4 a.p. .019, tr. .022; m^1 a.p. .0165, tr. .021. *Cotype* and referred specimens Amer. Mus. 8254, 8273, 8278, 9378, 9383, 9389, 9386, 9414; all from Pawnee Buttes.

Type figure.— Cope 1881, fig. 3, not reproduced here.[1]

Characters.— (Matthew, 1913) (1) Size medium, p^1–m^3 .123 (see Gidley); (2) protocone rather large, flattened oval, united half way down; (3) fossette borders simple, fossette areas contracted; (4) pli caballin rudimentary or absent; (5) metastylid not separate in p$_2$; (6) metastylid and metaconid pillars forming a rather narrow, double column; (7) heel of m$_3$ broad, with internal fold. (8) Lachrymo-malar fossæ broad, sessile, sub-united; (9) preorbital region rather short. (10) Ulnar shaft slender, united with radius except near proximal extremity; (11) metapodials and limb bones of moderate length and slenderness; (12) unguals rather narrow.

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[1] See also Cope, "The Perissodactyla," *The Amer. Naturalist*, Vol. XXI, No. 12, Dec. 1887, p. 1071, fig. 39, and "Hitherto Unpublished Plates of Tertiary Mammalia and Permian Vertebrata." Amer. Mus. Nat. History Monograph Ser. No. 2, 1915, Pls. cl., cli. Plates prepared under the direction of E. D. Cope for the U. S. G. S. Survey of the Territories, with descriptions of plates by W. D. Matthew. These plates represent the "Hayden Report, IV," of Cope's descriptions.

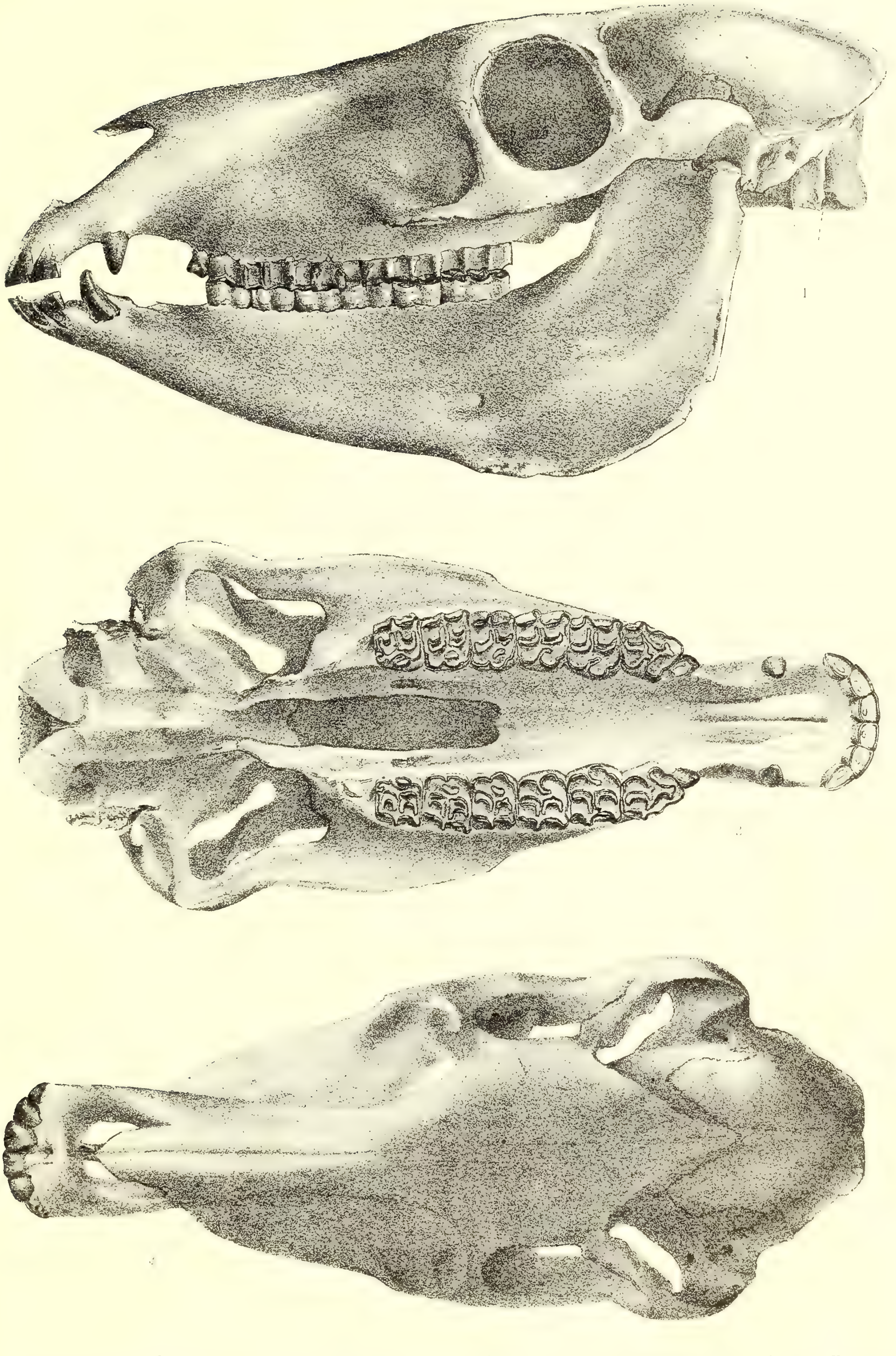


Fig. 85. Original figures of the skull of the type of *Merychippus sejunctus* Cope, Amer. Mus. Cope Coll. 8291. A male. After Cope, 1915, pl. CL. One-half natural size.

Gidley (1907) regarded this as close to the type of *M. labrosus.* Matthew (1915) regards it as pointing toward the *Protohippus perditus* type. The series of referred specimens give good comparative age characters and individual variation.

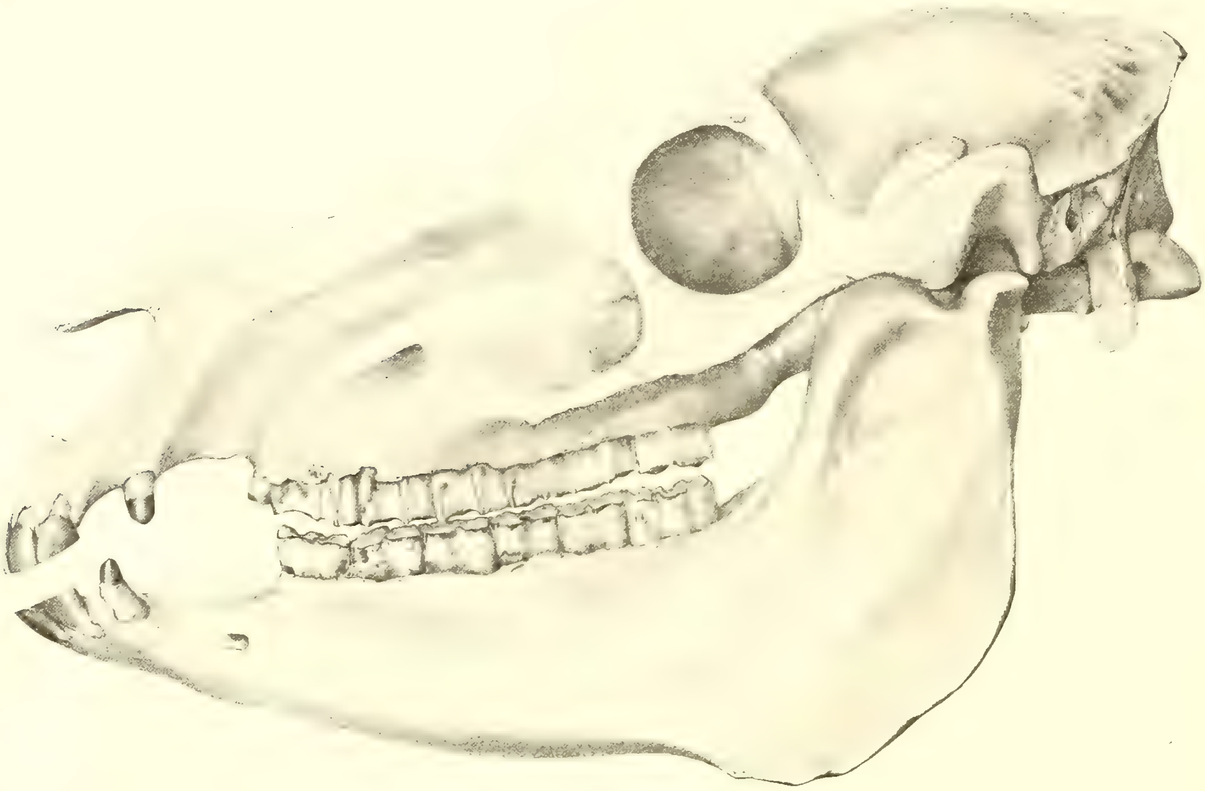


Fig. 85a. *Merychippus sejunctus* Cope, Amer. Mus. 8291. Skull of the type. One-half natural size. Drawn by B. Yoshihara under the direction of Osborn.

Merychippus sphenodus Cope, 1889.

Plates 10.2, 12, 15.1,2,3, 18.4, 43.1, 47.2, 48.3, 53.1. Text Fig. 87.

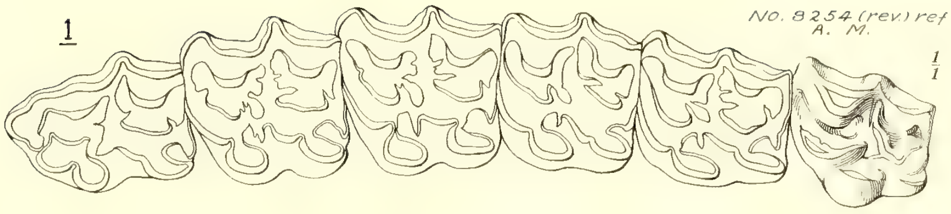
Hippotherium sphenodus Cope, Cope, E. D. "A Review of the North American Species of Hippotherium," *Proc. Amer. Philos. Soc.* Vol. XXVI, 1889 (sig. dated June 5, 1889), p. 449, no figure.

Horizon and locality.— (Cope) "Two superior molars of this species were obtained by me in the same locality as that furnishing the *H. paniense* [the Loup Fork beds of northeastern Colorado] and at the same time. Several years later I obtained two other molars from the same place, viz., the Pawnee Buttes of N. E. Colorado." Type collected by Edward D. Cope. (Osborn, 1918) The type of *M. sphenodus* is more progressive and appears to belong to a higher geologic level than the cotype.

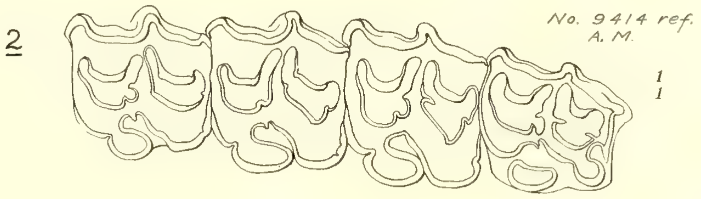
Type, cotype, and neotype.— "Specimen No. 1." *Type.* Crown of the second upper premolar, p^2 of the right side. Amer. Mus. Cope Coll. 8281. [Cope at this time (1889) was using the reverse enumeration of the premolars, hence the "third premolar" of his description (*op. cit.* p. 450) is really the second premolar, p^2.] Measurements: (Cope, Specimen No. 1) p^2 longitudinal .018; anteroposterior .025, transverse at column .019. *Cotype.* A left superior premolar, p^3 of the left side, of another individual, Amer. Mus. Cope Coll. 8281. Measurements: (Cope) longitudinal .015, anteroposterior .022, transverse .021. *Neotype* (Osborn). Amer. Mus. 1291.

Type figure.— 15.2, text Fig. 87 of this Memoir.

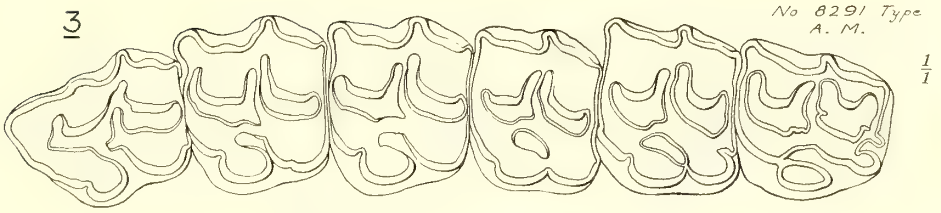
Referred specimens in the American Museum collections are Nos. 8251, 9390, 9400, 9408.



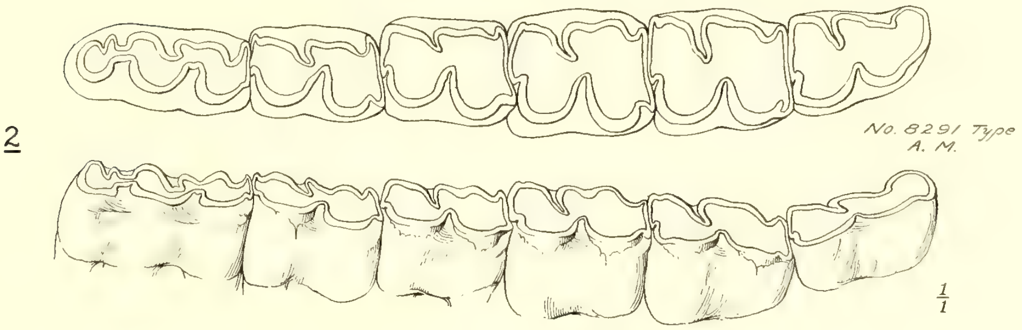
Merychippus sejunctus



Merychippus sejunctus



Merychippus sejunctus



Merychippus sejunctus

Fig. 86. *Merychippus sejunctus* Cope, upper and lower dentition. (Two upper figures, 1, 2) from a referred specimen, Am. Mus. 8254, the upper reversed in drawing. (Three lower figures, 3, 2.) From the type, Amer. Mus. 8291. All figures natural size.

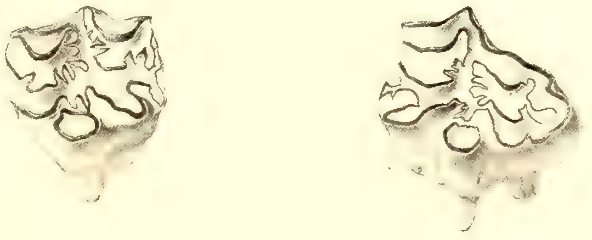


Fig. 87. *Merychippus sphenodus* Cope, Amer. Mus. Cope Coll. 8281. (Right) Type, p^2 of the right side; (left) cotype, ?p^3 of the left side. Both figures natural size. Drawings by S. Oka.

Cope observes (1889, p. 450): "The specimen No. 1 equals that of *H. speciosum* in dimensions; No. 2 is a little larger." These cotypes have not been identified; the species therefore rests on specimen No. 1.

Cope gave the following measurements for specimen No. 2, a third superior premolar: longitudinal .028, anteroposterior, .025, transverse at column .014. A right superior molar. Measurements: longitudinal .019, anteroposterior .022, transverse at column .022. This specimen has not been located in the Cope Collection (1917).

Characters.— (Osborn, 1918) (1) Type premolars with measurements as cited by Gidley above; (2) crowns of intermediate length, hypsodont; (3) protocones relatively narrow, suboval, with a spur tending toward protoloph; (4) enamel plications of protoconule consisting of two double folds in the crochet region; (5) enamel plications of metaloph and of hypostyle region complex.

The double plication of the pli caballin seems to distinguish this form from the *M. seversus, M. paniensis*, and *M. relictus* types. Similar double enamel folds of the pli caballin are observed in the types of *M. calamarius* and *M. republicanus* from the Lower Pliocene of the Santa Fé marls of New Mexico and of the Republican River, Nebraska, Procamelus zone.

Neotype.— Osborn (1918) rejects Cope's cotype (specimen 2, Plate 15.1) as belonging to a different species from the type, and selects as a *neotype* the skull Princeton Mus. 12291 (Plate 12), which agrees closely with the type of *M. sphenodus* (Plate 15.2) in the proportions of p^{2-3} and in the double pli caballin, pli prefossette, and pli postfossette, which are all progressive characters. This neotype (Princeton Mus. 12291) is recorded from the "lower levels of Pawnee Creek beds," as found west of Sand Cañon, Horsetail Creek drainage, Logan County, Col.

Merychippus campestris Gidley, 1907.

Plates 15.4,5, 19.3,4, 26.1, 44.1, 49.1, 50.3,7. Text Figs. 88, 89.

Merychippus campestris sp. nov., Gidley, J. W. "Revision of the Miocene and Pliocene Equidæ of North America," *Bull. Amer. Mus. Nat. Hist.* Vol. XXIII, Art. XXXV, Nov. 26, 1907, p. 928, no figure.

Horizon and locality.— Pawnee Buttes, Pawnee Creek formation, Colorado, Merychippus zone, Middle Miocene. Type collected by W. D. Matthew of the American Museum Expedition of 1898.

Type.— Amer. Mus. 9096. "Upper molar-premolar series of the left side associated with the lower jaws, fragments of skull, vertebræ, and portion of fore and hind limbs and feet." Measurements: (Gidley) superior molar-premolar series .1445; p^4 a.p. .023, tr. .0255; m^1 .0205, tr. .024; length of Mtc. III .175; length of femur .244; length of tibia .275.

Type figure.— Plates 15.4, 19.3, 44.1, 49.1, 50.3,7, text Figs. 88, 89.

Characters.— (Gidley, 1907, pp. 928, 929) (1) Superior molars of the same general appearance as those of *Pliohippus spectans* Cope, but differing in the following characters: (2) the molars with shorter crowns; (3) external cones (*pa, ma*) thicker transversely, making less transverse width for the fossettes; (4) protocone smaller and more rounded, being nearly circular in outline; (5) as in *P. spectans* the horns of the fossettes end in broadly open loops; (6) the enamel borders are very simple throughout. (7) Lower jaws comparatively long and slender. (8) Mtc. III moderately short and heavy, lateral metacarpals very much reduced. (Osborn, 1918) (9) Enamel plications very simple; (10) protocone extended inward more than hypocone, suggesting some of the simple *Pliohippus* types of molar.

(Matthew, 1913) A referred skull and jaws, Amer. Mus. 9459, with old teeth, gives important comparative characters.

Merychippus eoplacidus sp. nov.

Plates 20.1, 39.6, 44.2, 47.1, 49.2, 54.2. Text Fig. 90.

Horizon and locality.— Pawnee Creek beds, Pawnee Buttes, northeastern Colorado. Middle Miocene. Type collected by F. B. Loomis, of the American Museum Expedition of 1901.

Type.— Amer. Mus. 9347. Lower jaw, cervicals, fore and hind feet, humerus, ulno-radius, parts of femur and tibia, all of one individual.

Type figure.— Plates 20.1, 39.6, 44.2, 47.1, 49.2, 54.2, text Fig. 90 of this Memoir.

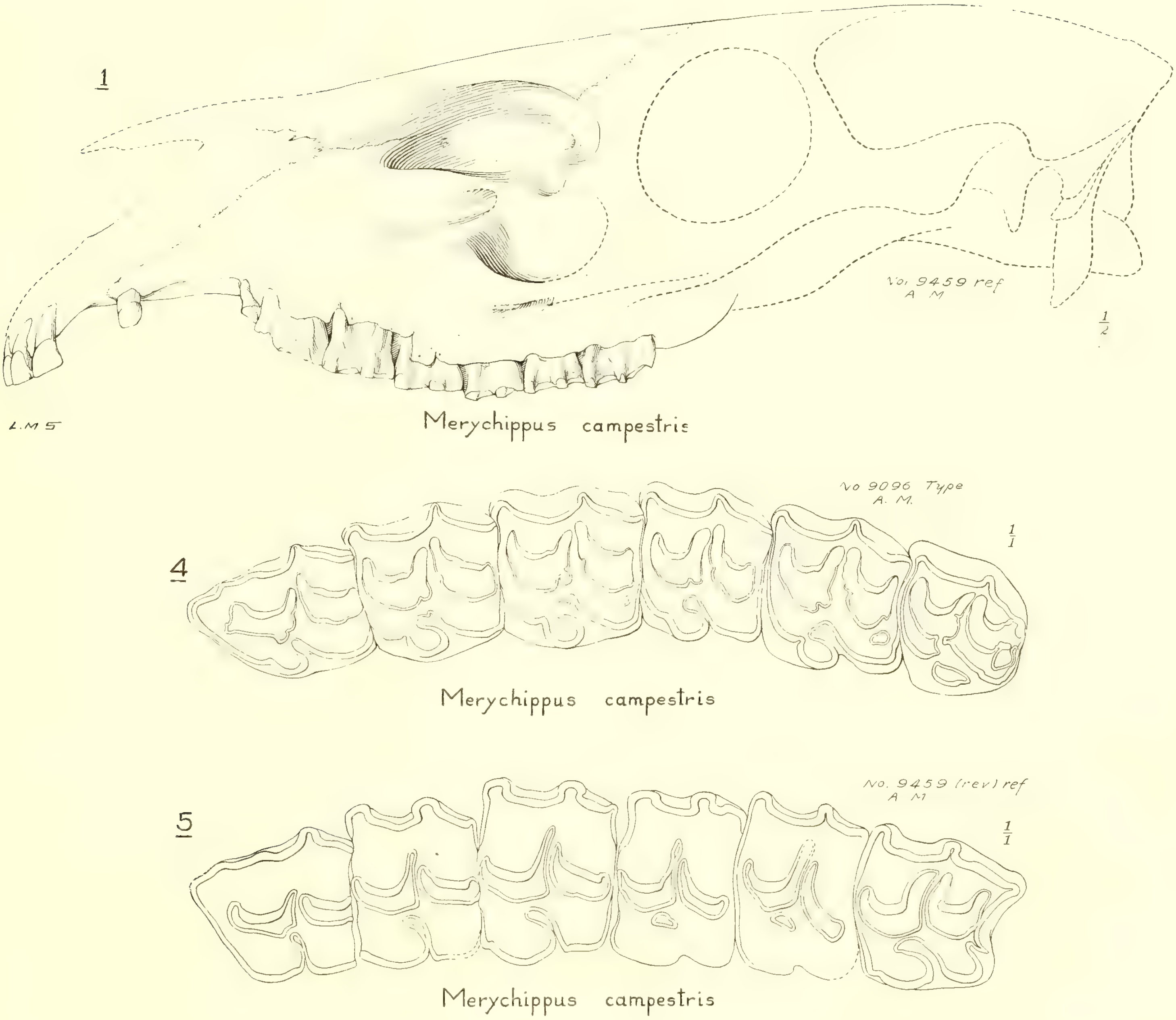


Fig. 88. *Merychippus campestris* Gidley. (4) Amer. Mus. 9096, crown view of the superior premolar-molar teeth of the type, p^2–m^3. (1) Skull of a referred specimen, Amer. Mus. 9459. (5) Crown view of the grinding teeth of the same specimen, Amer. Mus. 9459, p^2–m^3. A male. Skull one-half natural size, teeth natural size.

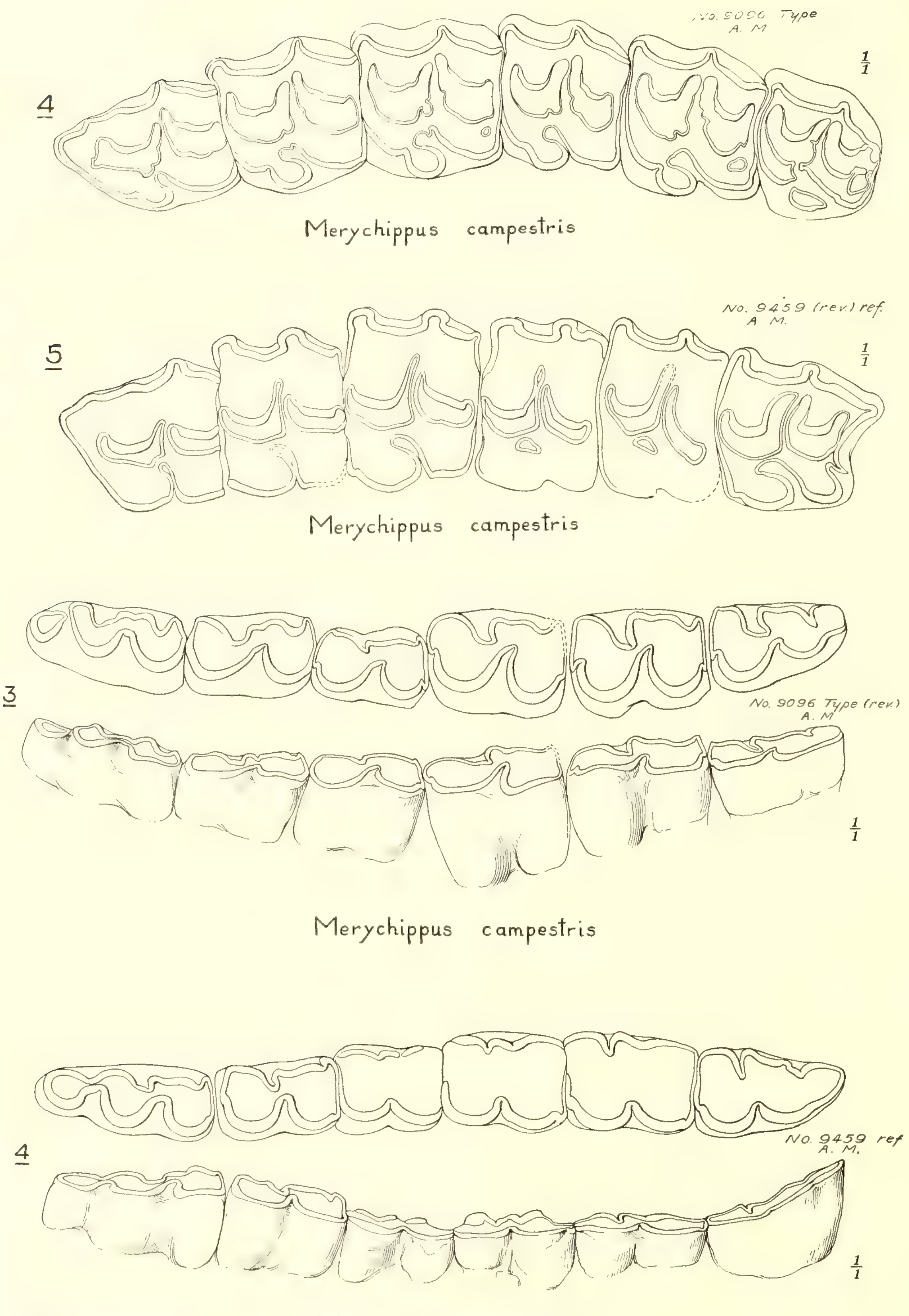


Fig. 89. *Merychippus campestris* Gidley. Side and crown views of the upper and lower dentition of the specimens figured in Fig. 88, Am. Mus. 9096, type, Am. Mus. 9459, referred specimen. Upper and middle figures reversed in drawing. All figures natural size.

Characters.— (Matthew, 1913) (1) Metastylid not separate on p^2; (2) metaconid-metastylid pillar forming a narrow column, prominent but imperfectly divided; (3) heel of m_3 small, simple, somewhat broader below; (4) antorbital region rather long, diastema one-third of the length of the grinding tooth row, symphysis mandibuli narrow, rather shallow but incisive row rounded; (5) shaft of ulna very slender, reduced almost to a thread but imperfectly united proximally and separate in distal half; (6) metapodials long and slender, lateral digits much reduced.

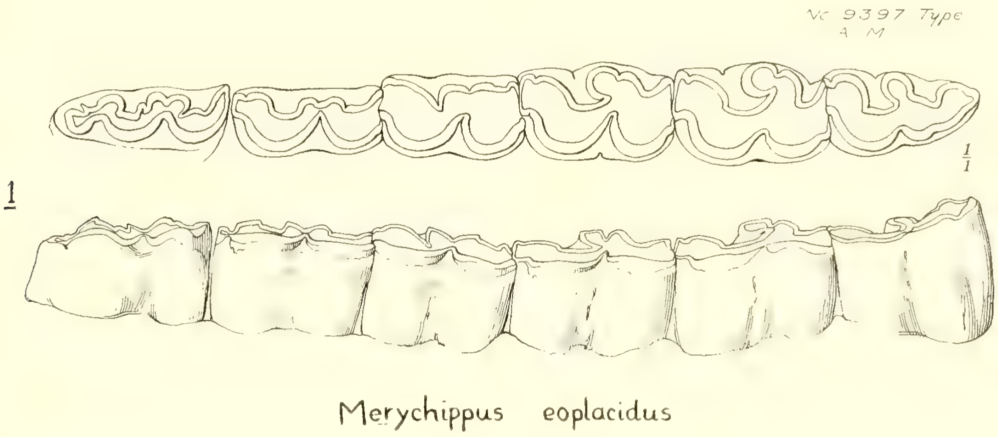


Fig. 90. *Merychippus eoplacidus* Osborn, Amer. Mus. 9397, left lower grinding teeth of the type. Natural size.

Merychippus proparvulus sp. nov.

Plates 11.3, 15.6,7, 20.3, 54.1. Text Fig. 91.

Horizon and locality.— Pawnee Creek beds, Pawnee Buttes, northeastern Colorado. Middle Miocene. Type collected by F. B. Loomis of the American Museum expedition of 1901.

Type.— Amer. Mus. 9394. Upper jaws, vertebræ, hind foot, and parts of limb bones; teeth much worn.

Paratype.— Amer. Mus. 9398, a lower jaw, associated with two upper molars, moderately worn. Middle Miocene.

Type figure.— Plates 11.3, 15.6, 54.1, text Fig. 91 of this Memoir.

Characters.— (Matthew, 1913) (1) Size medium. (2) Protocone strongly united with protoconule in an early stage of wear; (3) prefossette open until the tooth is deeply worn, the crochet uniting with metaconule only toward the base; (4) fossette borders nearly simple (?) due to extreme wear; (5) absence of pli caballin (?) due to extreme wear; (6) metaconid-metastylid pillars forming a narrow column indistinctly divided by shallow groove; (7) m^3_3 large, heel of m_3 simple, elongate. (8) No malar fossa. (9) Ulnar shaft rather heavy, in proximal part at least united with radius one-third down, distal half unknown; (10) metatarsals long, shafts of lateral digits moderately reduced; (11) ungual phalanges rather narrow.

Merychippus eohipparion sp. nov.

Plates 20.2, 44.3, 47.3, 49.3, 50.4,8, 54.3. Text Fig. 92.

Horizon and locality.— Pawnee Creek beds, Pawnee Buttes, northeastern Colorado. Middle Miocene. Type collected by Barnum Brown of the American Museum expedition of 1901.

Type.— Amer. Mus. 9402. Lower jaws, fore and hind limbs and feet, and several vertebræ, all belonging to a single individual.

Type figure.— Plates 20.2, 44.3, 47.3, 49.3, 50.4,8, 54.3, text Fig. 92 of this Memoir.

Characters.— (Matthew, 1913) (1) Metaconid well separated from metastylid on p_2; (2) metaconid-metastylid pillars widely separated, deeply grooved in upper part of crown, flattening out at base of crown; (3) outer surface of protoconid and metaconid not flattened; (4) anterior cingulum forming a prominent plate externally on lower half of tooth, wanting above; (5) heel of m_3 small toward crown, elongate toward the base, the crescents strongly recurved at inner side toward the base of tooth; (6) incisors large. (7) Antorbital region of skull moderately elongate. (8) Shaft of ulna moderately reduced, imperfectly united in the immature type; (9) metapodials long, lateral digits moderately reduced; (10) ungual phalanges narrow and short.

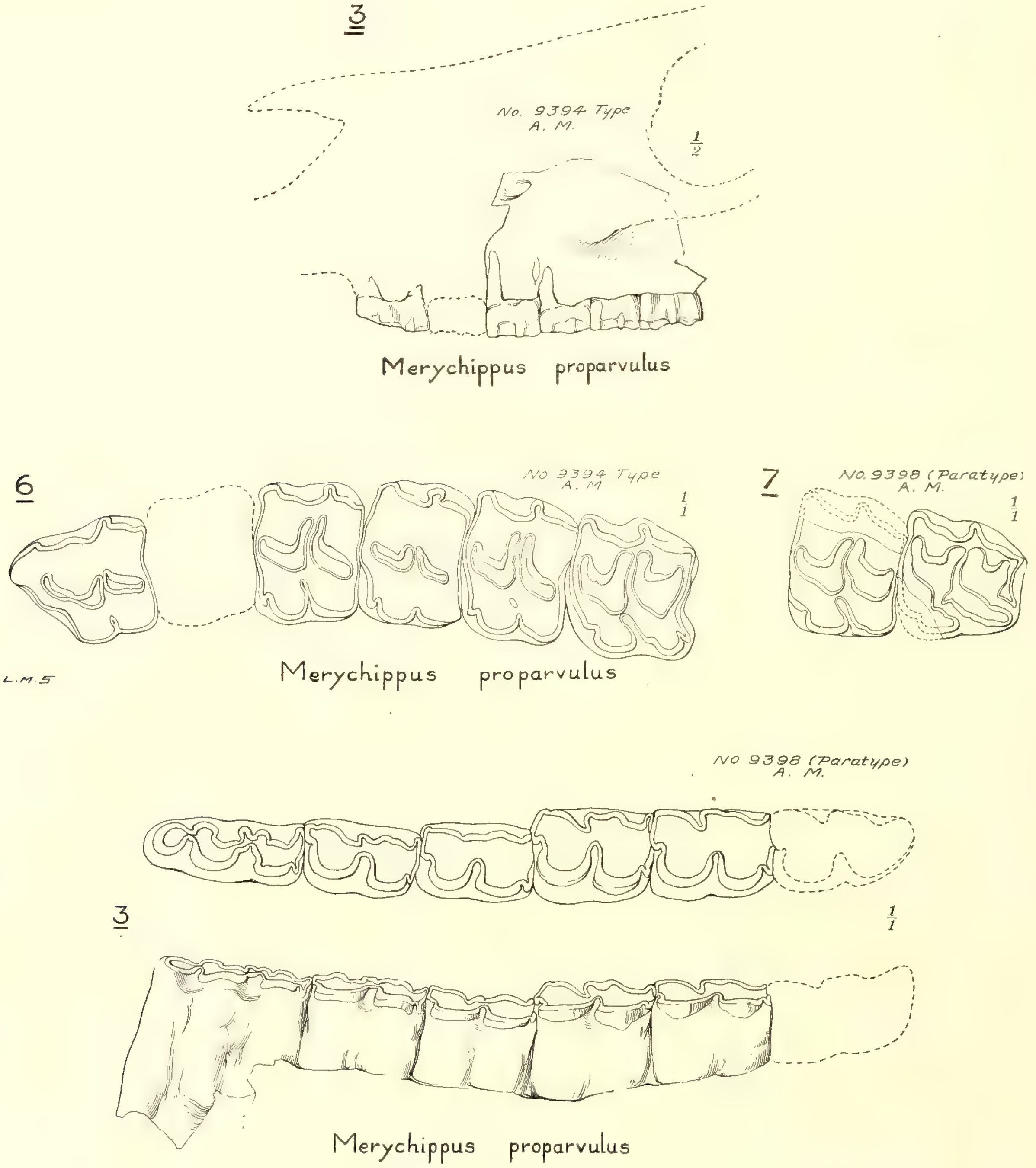


Fig. 91. *Merychippus proparvulus* Osborn. (Upper) Amer. Mus. 9394, side view of maxilla fragment of the type, one-half natural size. (6) Crown view of the superior grinding teeth of the type, of the left side. (7) Amer. Mus. 9398, crown view of left superior grinding teeth of a paratype. (Lower) Outer and crown views of the lower grinding teeth of the same paratype. All figures of teeth natural size.

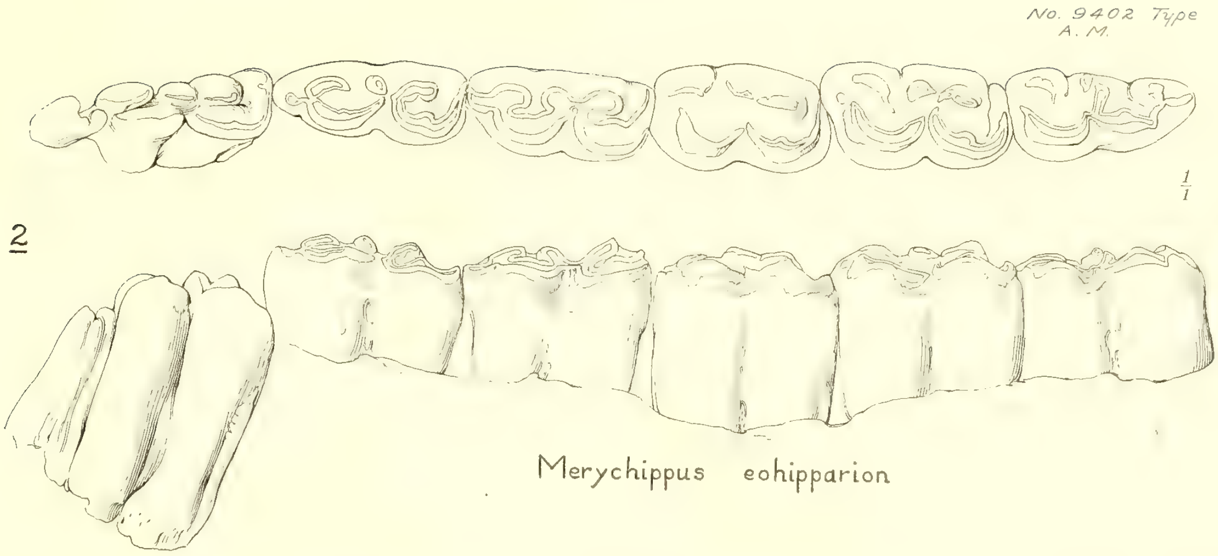


Fig. 92. *Merychippus eohipparion* Osborn, Amer. Mus. 9402. Crown and side views of the inferior grinding teeth of the type, p_2–m_3. Natural size.

Merychippus missouriensis Douglass 1908

Text Fig. 93.

Merychippus ? missouriensis sp. nov., Douglass, Earl. "Fossil Horses from North Dakota and Montana," *Ann. Carnegie Mus.* Vol. IV, Nos. III, IV, April, 1908, p. 274, type, Pls. lxvi, lxviii, figs. 1, 2, paratype, Pl. lxvii, fig. 5.

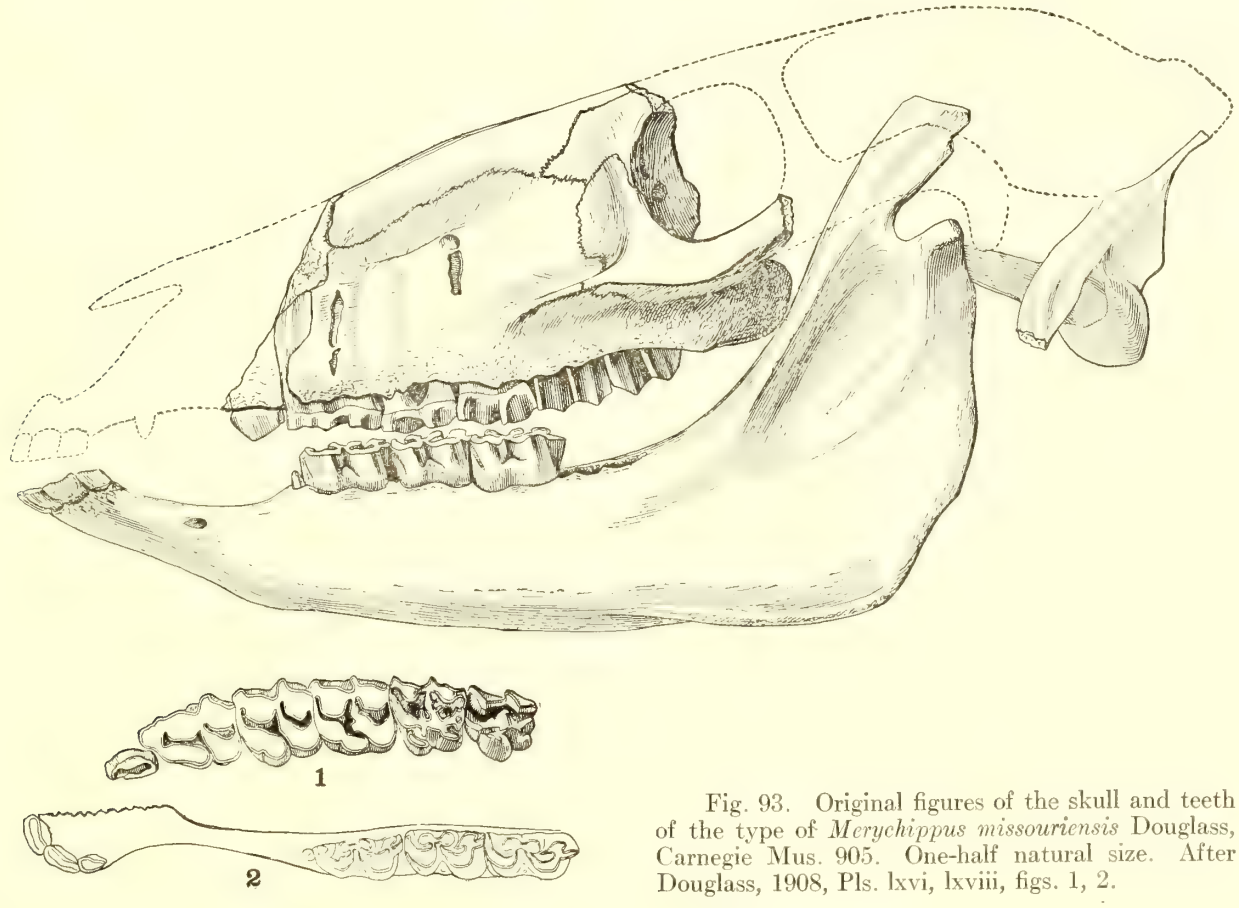


Fig. 93. Original figures of the skull and teeth of the type of *Merychippus missouriensis* Douglass, Carnegie Mus. 905. One-half natural size. After Douglass, 1908, Pls. lxvi, lxviii, figs. 1, 2.

Horizon and locality.— (Douglas, p. 274) "These beds form a part of the bluffs along the eastern side of the Missouri River north of Confederate Creek and east of Winston in Montana. The type was collected by Earl Douglass and Ray Roberts in 1902."

Type.— Carnegie Mus. 905. (Douglass, p. 274) "The type of this species is a portion of a skull, a mandible, a radius, two femora, two complete and two incomplete metapodials, also numerous fragments." Measurements: (Douglass, p. 274) dp^{1-4} .0842; m^1 a.p. .022, tr. .021; m^2 a.p. .021.

Paratype.— From the same locality, only a few feet away, a nearly complete hind foot, Carnegie Mus. 858, was obtained. This undoubtedly belongs to the same species as the type, and the age of the two individuals was nearly the same, as shown by corresponding portions of mandibles with teeth.

Type figure.— Text Fig. 93 of this Memoir.

Characters.— (Douglass, p. 274) (1) Lachrymal fossa long and moderately deep; (2) malar pit with steep posterior side, bounded below by a thin, shelf-like malar-maxillary ridge. (3) Temporary molars brachyodont or brachy-hypsodont; (4) permanent molars curved and strongly hypsodont; (5) both series of teeth with a coating of cement which is not very thick; (6) enamel lakes simple with only one or two simple enamel folds on each; (7) protocone and hypocone laterally compressed, the former separate from the protoconule but having an angular projection toward the latter; (8) first temporary lower molar minute; (9) intermediate external conule on lower temporary molars concave on the inside, more or less flattened on the outside. (10) Metapodial nearly ninety per cent. of the length of the radius and eighty-four per cent. of the length of the femur exclusive of the proximal epiphysis.

(Matthew, 1913) The deciduous premolars are moderately high-crowned. This general type is difficult to distinguish from *M. isonesus* Cope, with which it agrees in size.

PROCAMELUS-MERYCHIPPUS CALAMARIUS ZONE. 11. LATE UPPER MIOCENE.

This zone is distributed in California and New Mexico. It is typified at Barstow by the presence of progressive species of *Merychippus*, such as *M. calamarius* Cope.

Merychippus sumani Merriam 1915.

Text Fig. 94.

Merychippus sumani, n. sp., Merriam, John C. "New Horses from the Miocene and Pliocene of California," *Univ. Calif. Publ. Bull. Dept. Geol.* Vol. 9, No. 4, Nov. 22, 1915, pp. 49–50, fig. 1.

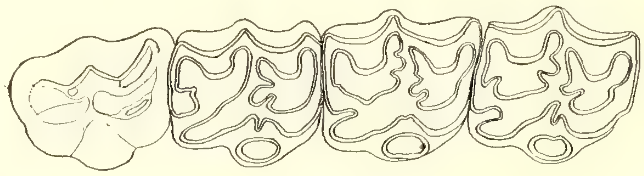


Fig. 94. Original figure of the type of *Merychippus sumani* Merriam, Univ. Cal. Pal. Coll. 21422, p^4–m^3. Natural size. After Merriam, 1915, fig. 1, p. 51.

Horizon and locality.— Barstow, Barstow formation, Upper Miocene, Mohave Desert, California. Type collected by John R. Suman.

Type.— Univ. Cal. Pal. Coll. 21422. Series of upper molars of the right side, p^4–m^3. Measurements: m^1–m^3 .057; p^4 a.p. .022, tr. .0208; m^1 a.p. .019, tr. .0194, height of crown .0285.

Type figure.— Text Fig. 94 of this Memoir.

Characters.— (Merriam, 1915) "Upper cheek-teeth much smaller than in typical *Merychippus calamarius* or in *M. intermontanus.* Crowns of cheek-teeth considerably elongated, markedly curved, and well cemented; height of the crowns often equal approximately to twice their width. Protocone round, tending toward circular form in cross-section, and discrete up to a stage of very advanced wear. Enamel bordering the fossettes commonly more complicated than in any of the larger *Merychippus* forms of the Barstow Miocene."

This species includes the smallest members of the *Merychippus* series in the Barstow Miocene.

Merychippus intermontanus Merriam 1915.

Text Fig. 95.

Merychippus intermontanus, n. sp., Merriam, J. C. "New Horses from the Miocene and Pliocene of California," *Univ. Cal. Publ. Bull. Dept. Geol.* Vol. 9, Nov. 4, Nov. 22, 1915, pp. 50–52, fig. 2, 3.

Horizon and locality.— Barstow, Barstow formation, Upper Merychippus zone, Upper Miocene, Mohave Desert, California. From Locality 1401. Name of collector not given.

Type.— Univ. Cal. Pal. Coll. 21400. Complete superior molar series of right side, p^2–m^3. Measurements: premolar-molar series, p^2–m^3 .146; p^4 a.p. .0249, tr. .921; m^1 a.p. .024, tr. .0217.

Type figure.— Text Fig. 95 of this Memoir.

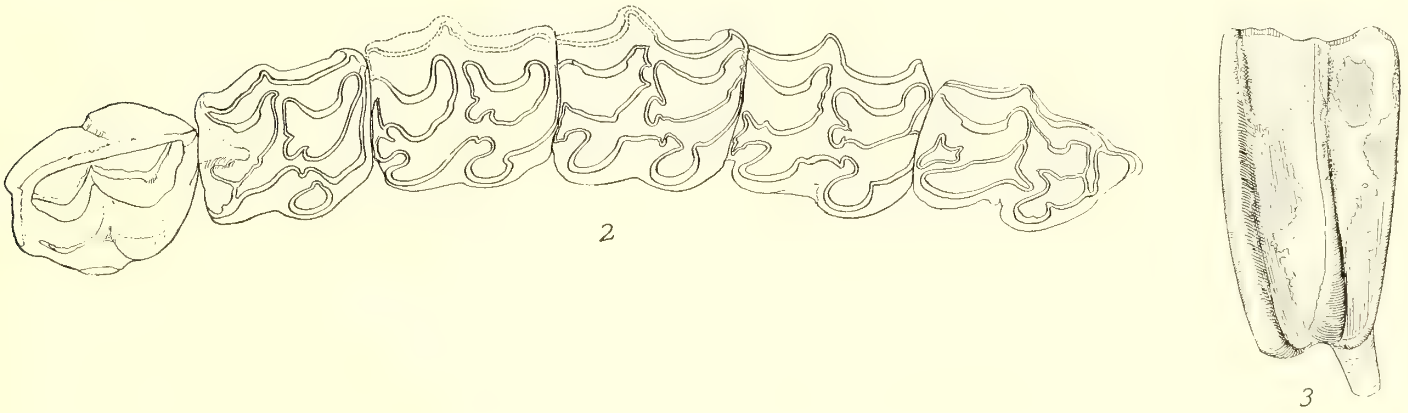


Fig. 95. Original figures of the type of *Merychippus intermontanus* Merriam, Univ. Cal. Pal. Coll. 21400, p^2–m^3. After Merriam, 1915; crown view, fig. 2, p. 51, outer view of m^2, fig. 3, p. 51. Natural size.

Characters.— (Merriam, p. 50) "Cheek-teeth large; crowns long, strongly curved, heavily cemented. Protocone of upper cheek-teeth uniting early with protoconule. Enamel walls bordering the fossettes comparatively simple."

Merriam (p. 50) distinguishes the type of this species from that of *M. calamarius* by its larger size, longer crowns, heavier cementation, and more pronounced tendency toward union of the protocone and protoconule even in young individuals; also in its closer approach to the *Protohippus* type. It is distinguished from *Protohippus* by the presence of less cement on the molar crowns in a number of referred specimens.

Merychippus californicus Merriam 1915.

Text Fig. 96.

Merychippus californicus, n. sp., Merriam, John C. "Tertiary Vertebrate Faunas of the North Coalinga Region of California, a Contribution to the Study of Palæontologic Correlation in the Great Basin and Pacific Coast Provinces," *Trans. Amer. Philos. Soc.* N. S. Vol. XXII, Pt. III, 1915, p. 197, figs. 3a, 3b, 3c, 3d.

Horizon and locality.— From Merychippus zone between typical "Temblor" and "Big Blue," north Coalinga region, Fresno County, California. Type collected by Chester Stock and C. L. Moody.

Type.— Univ. Cal. Pal. Coll. 21247. First superior molar of the left side, m^1, from locality 2124; also from same locality, between forty and fifty upper and lower molars, several incisors, limb and foot elements. (Merriam) "The upper and lower molars seem all referable to a single species." Measurements: (Merriam, p. 201) m^1 a.p. .0187, tr. .0201, height of mesostyle, worn, .0281.

Type figure.— Text Fig. 96 of this Memoir.

Characters.— (Merriam, 1915) (1) Molars of more slender form than in *M. isonesus,* otherwise in some respects similar; (2) protocone separate from protoconule almost to base of crown, connected only in very old, much worn teeth; (3) protocone round [oval] with a slight lateral compression [suboval]; (4) a spur extending toward protoconule; (5) enamel folding moderately complex, approximating that of *M. isonesus;* (6) superior molars somewhat narrow in cross section and somewhat more hypsodont than in *M. isonesus;* (7) type of upper molar leading toward *Hipparion;* (8) lower cheek teeth closely resembling those of *M. isonesus* in form and dimensions.

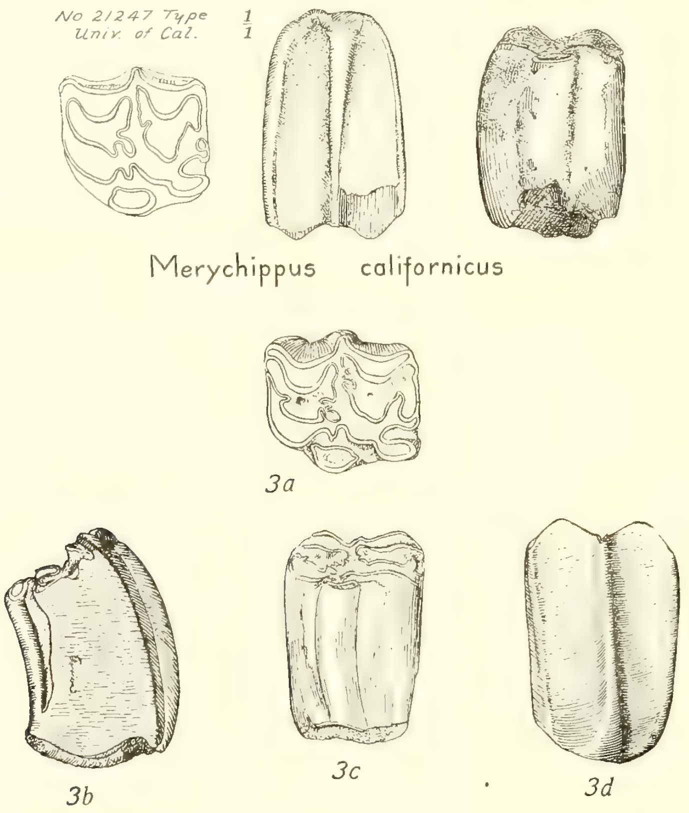


Fig. 96. (Upper) Type of *Merychippus californicus* Merriam, Univ. Cal. Pal. Coll. 21247, superior molar of left side, m^1. Crown, external, and internal views. (Lower) Original figures of a referred specimen of *M. californicus* Merriam, Univ. Cal. Pal. Coll. 21217, m^1 of the left side. 3a Crown view, 3b posterior view, 3c internal view, 3d external view. After Merriam, 1915, p. 197.

Merychippus insignis Leidy 1857.

Plates 17.5, 25.3. Text Fig. 97.

Merychippus insignis, Leidy, Joseph. "Notices of Extinct Vertebrata Discovered by F. V. Hayden, during the Expedition to the Sioux Country under the Command of Lieut. G. K. Warren," *Proc. Acad. Nat. Sci. Phila.* Vol. VIII, 1856 (sig. printed April or later, 1857), p. 311, no figure. "The Extinct Mammalian Fauna of Dakota and Nebraska," *Jour. Acad. Nat. Sci. Phila.* (2) Vol. VII, 1869, pp. 296–299, Pl. xvii, figs. 3–4.

Horizon and locality.— (Leidy) "From the tertiary beds of Bijoux Hills on the Upper Missouri." Brule Co., So. Dak. Lower Pliocene or Upper Miocene. Type collected by F. V. Hayden.

Type.— Acad. Nat. Sci. Phila. Coll. (cast Amer. Mus. 10770.) (Leidy, 1857) "Founded upon a first and second molar of the upper jaw of a remarkable equine animal, in the structure of the teeth approximating the ruminant family." (Gidley, 1907) "Two right upper milk molars, dp^{2} and dp^{3}, in a fragment of the maxillary." Measurements: (Gidley 1907) dp^{2} a.p. .022+, tr. .0175; dp^{3} a.p. .022, tr. .019.

Type figure.— Text Fig. 97 of this Memoir.

Characters.— (Leidy, 1857) "The teeth are inserted by distinct fangs; and the crowns strikingly resemble the true molars of ruminants. There are four demiconoidal lobes holding the same relationship with one another as in the latter, especially as in the Deer. The outer lobes have almost the exact form as in the true molars of *Oreodon.* The inner lobes resemble those of ruminants, but are complicated with accessory folds as in the horse. No cementum fills up the interspaces of the lobes nor does it appear to have existed as part of the structure of these teeth."

This is the genotype of *Merychippus.* Although founded on milk teeth, the genus is well characterized. The species awaits final determination. Its characters are (Osborn, 1918): (1) absence of cement on the deciduous teeth; (2) brachyodont, intermediate size; (3) small, pear-shaped form of deuterocone and tetartocone; (4) metaloph and hypostyle ptychoid and continuous; (5) protoconule simple, crescentic; (6) external ribs well marked on ectoloph.

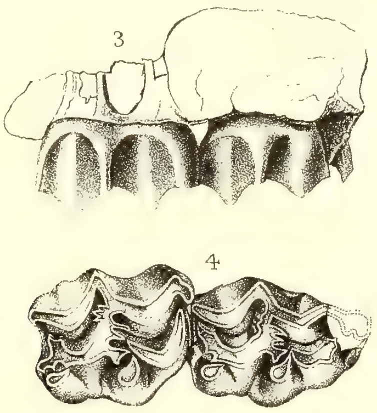


Fig. 97. Original figures of the type of *Merychippus insignis* Leidy, Acad. Nat. Sci. Phila. Coll. (cast Amer. Mus. 10770), deciduous premolars of the right side, dp^{2}, ^{3}. Natural size. After Leidy, 1869, Pl. xvii, figs. 3–4.

PROCAMELUS-MERYCHIPPUS CALAMARIUS ZONE. 12. UPPER LEVELS.

This zone is typified in the Santa Fé marls of New Mexico.

Merychippus calamarius Cope 1875.

Plates 11.4, 17.8, 18.2,6. Text Fig. 98.

Hippotherium calamarium, Cope, sp. nov., Cope, E. D. "On Some New Fossil Ungulata," *Proc. Acad. Nat. Sci. Phila.* Vol. XXVII, 1875 (sig. dated July 27, 1875), pp. 259–260, no figure. Same description in "Report on the Geology of that Part of Northwestern New Mexico Examined During the Field-Season of 1874, by E. D. Cope, Paleontologist and Geologist," *Appendix LL, Ann. Rept. Chief of Engineers in Ann. Rept. Geogr. and Geol. Surveys and Explorations West of the 100th Meridian, in Nevada, Utah, Colorado, New Mexico, and Arizona* (Wheeler), 1875, p. 70, no figure. "Report upon the Extinct *Vertebrata* obtained in New Mexico by parties of the expedition of 1874," etc., *Geogr. Surveys West of the One Hundredth Meridian* (Wheeler), Vol. IV, Palæontology, 1877, pp. 321–322, Pl. lxxv, figs. 1, 1a.

Horizon and locality.— (Cope, 1875) San Ildefonso, Santa Fé marls, Procamelus zone, New Mexico. Type collected by E. D. Cope. (Cope, 1889, p. 451[1]) "The *H. calamarium* has been found especially abundant in the Loup Fork beds of Pojuaque near Santa Fé, New Mexico."

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[1] Cope, E. D. "A Review of the North American Species of Hippotherium," *Proc. Amer. Philos. Soc.* Vol. XXVI, June 5 and Sept. 11, 1889, pp. 429–458, figs. 1–24a (p. 451).

Type.— U. S. Nat. Mus. 2572. (Cope, 1875, p. 259) "This three-toed horse is indicated by the oral and palatine parts of the skull with the superior dental series of both sides, together with one mandibular ramus with all its teeth, of an individual from near San Ildefonso; and also probably by molar teeth of two individuals from the Loup Fork beds of Colorado." Measurements: (Cope, 1875, p. 260) superior premolar-molar series, p^1–m^3, .134; superior molars, m^1–m^3, .062.

Type figure.— Text Fig. 98 of this Memoir.

Characters.— (Cope, 1875) (1) "The typical specimen belongs to an adult animal, and was taken from the matrix by myself, without admixture of others." (2) Protocone column large, its centre anterior to the middle transverse line of the crown, an angular projection toward the protoconule, actually connecting with the protoconule in m^2; (3) dentinal band connecting the inner crescents [pl ml], giving off two or rarely one fold [double pli caballin] in the crochet region; (4) borders of fossettes much plicate, anterior border of protoconule giving off from four to six folds; (4) posterior border of postfossette exhibits one deep fold, which is generally bifurcated [hypostyle region]; (5) p^1 small, two-rooted; (6) no basal cingulum on either jaw; (7) posterior molar, m_3, smaller than the three preceding it.

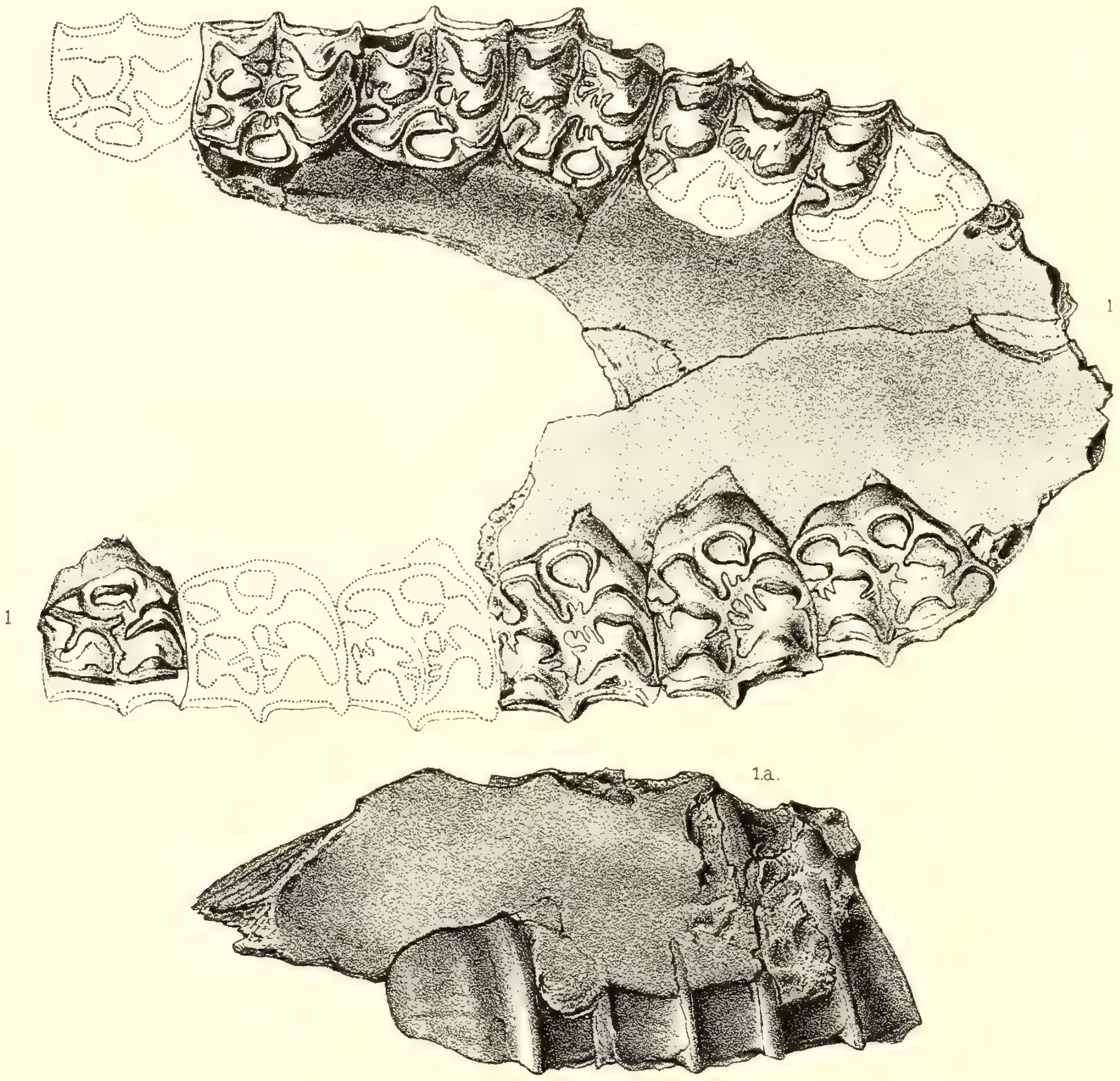


Fig. 98. Original figures of the type of *Merychippus calamarius* Cope, U. S. Nat. Mus. 2572. (1) Palatal view, (1a) "external view of maxillary bone, containing three anterior molars of the left side" (Cope). Natural size. After Cope, 1877, Pl. lxxv, figs. 1, 1a.

(Matthew, 1913) (8) Grinding teeth extremely long-crowned; (9) protocone separate to about one-third from base, suboval on premolars, more flattened on molars; (10) plications of enamel lake borders disappearing in well (two-thirds or more) worn teeth; (11) pli caballin fold double, disappearing about one-fourth from base; (12) metastylid not separate on p_2. (13) Lachrymal fossa apparently large; (14) malar fossa variable, not very deep.

Matthew (1913) refers to this species a large series of upper and lower jaws and teeth from the Snake Creek beds (Lower Pliocene) of Nebraska; also jaws and teeth from the Madison Valley, Montana, and from the Republican River (Lower Pliocene) of Nebraska.

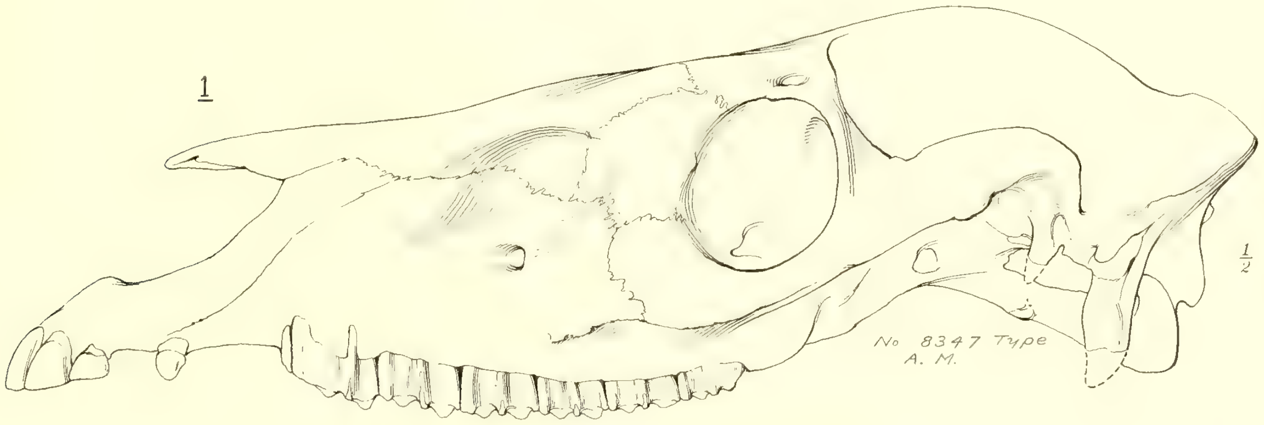
Referred specimens are Amer. Mus. 13901a, 14001, 14003, 14014.

Merychippus stylodus Merriam 1915. *Nomen nudum.*

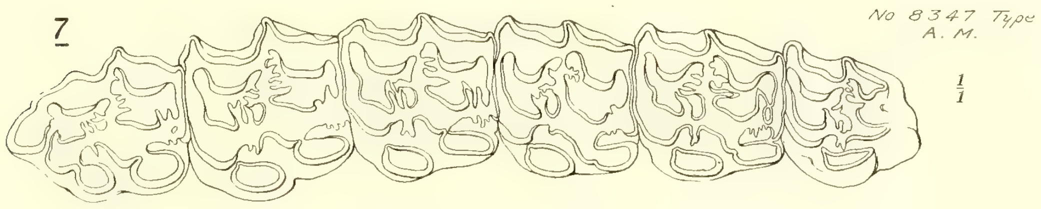
Merriam (letter, Oct. 29, 1915) considers that the species *Merychippus stylodus* should be eliminated as it appears to represent quite closely the typical *M. calamarius Cope.*

PLIAUCHENIA-PERACERAS ZONE. 14. LOWER PLIOCENE.

This zone is believed to contain the last surviving members of the genus *Merychippus*, with which are found *Pliohippus*, *Hipparion*, *Hypohippus*, and other genera.



Merychippus republicanus



Merychippus republicanus

Fig. 99. *Merychippus republicanus* Osborn, Amer. Mus. 8347. (1) Skull of the type, side view. (7) Crown view of the type superior grinding teeth of the left side, p^2–m^3. Skull one-half natural size, teeth natural size.

Merychippus republicanus sp. nov.

Plates 10.1, 17.7. Text Fig. 99.

Horizon and locality.— Driftwood Creek, Republican River formation, Peraceras or Upper Procamelus zone, western Nebraska. Early phase of Lower Pliocene. Type collected by W. Brous, 1879.

Type.— Amer. Mus. Cope Coll. 8347. A complete skull, finely preserved, teeth one-fourth worn, with associated vertebræ and parts of fore limb. This skull was referred by Cope to *Hippotherium speciosum* Leidy (= *Hippodon speciosus*), an indeterminate species. Referred specimen, lower jaws, Amer. Mus. Cope Coll. 8341, from the same locality and formation.

Type figure.— Plates 10.1, 17.7, text Fig. 99 of this Memoir.

Characters.— (Matthew, 1913) (1) Medium size, p^1–m^3 .0255; (2) protocone separate about half way down, oval on premolars, somewhat flattened on molars; (3) enamel of fossettes strongly folded to about half way down the crown, (4) double pli caballin fold, as in *M. calamarius;* (5) plication of enamel of metaloph and hypostyle region more elaborate and branching than in *M. calamarius;* (6) metastylid of p_2 posterior in position; (7) metaconid pillar distinct but very small; (8) metastylid moderately separated in p_2, in m_3 by shallow groove, anteroexternal cingulum fold distinct in half worn teeth. (9) Lachrymal fossa rather small and shallow, not sharply marked; (10) no malar fossa; (11) preorbital region short; (12) postcanine diastema one-fifth length of cheek teeth. Foot characters based on doubtfully referred specimens; (13) metacarpals short, moderately slender, lateral digit complete though considerably reduced; (14) trapezium nodule very small and solidly coössified with trapezoid.

Among the above characters those assigned to the lower jaw are based on specimens of somewhat doubtful reference.

This species seems to represent an advance upon the *M. calamarius* type in the more extreme plication of its enamel foldings.

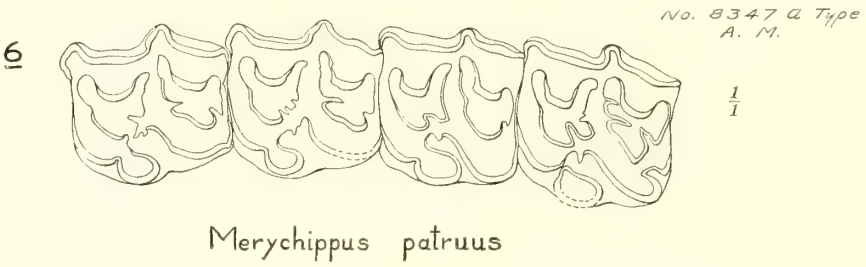


Fig. 100. Type of *Merychippus patruus* Osborn, Amer. Mus. Cope Coll. 8347a, p^3–m^2. Natural size.

Merychippus patruus sp. nov.

Plate 17.6. Text Fig. 100.

Horizon and locality.— Driftwood Creek, Republican River formation, Nebraska, Peraceras or Upper Procamelus zone, Lower Pliocene. This type was found near the type skull of *M. republicanus.* Type collected by W. Brous, 1879.

Type.— Amer. Mus. Cope Coll. 8347a. Left upper jaw containing p^3–m^2.

Type figure.— Plate 17.6, text Fig. 100 of this Memoir.

Characters.— (Matthew, 1913) (1) Of medium size. (2) Premolars relatively narrow transversely, molars relatively broad transversely; (3) in well worn teeth protocone strongly united to protoloph; (4) protoloph separated from metaloph until teeth are considerably worn; (5) hypocone absorbed in metaloph at an early stage of wear, distinct only in m^2 of the type; (6) protocone of round-oval form, anterior in position; (7) enamel lakes in well worn teeth nearly simple; (8) pli caballin fold of crochet region single in well worn teeth, crochet triple in unworn teeth; (9) parastyle moderately broad on upper premolars, narrow on upper molars; (10) metastyle narrow in all teeth, narrowing rapidly at the base.

The name *M. patruus* (Latin, *patruus* meaning father's brother) is suggested by Matthew in reference to the supposed affinity of this animal to *Protohippus parvulus,* the Pliocene stage, from which *M. patruus* is distinguished by (1) larger size, (2) by the shorter crowns of the teeth, (3) the sudden narrowing of the mesostyle, as well as (4) by the transverse narrowness of the premolars.

GENUS **PROTOHIPPUS** Leidy 1858.

Proc. Acad. Nat. Sci. Phila. 1858, pp. 26–27.

Genotype.— *Protohippus* (*Equus*) *perditus* Leidy, from the Niobrara River, near Fort Niobrara, Procamelus-Hipparion zone, Lower Pliocene, Nebraska.

The twelve species which have been referred to the generic stage of *Protohippus*, beginning with the *P. perditus* Leidy of 1858 and ending with the *P. secundus* Osborn of 1918, are known within a relatively short geologic period, namely, the Procamelus-Hipparion zone, now regarded as the typical American Lower Pliocene, along the Niobrara River, Nebraska, along the Little White River, South Dakota, in the Clarendon formation of Texas, in the Tehuichila of Vera Cruz, Mexico; also from the somewhat more recent and doubtfully separated Peraceras zone of the Republican River, Driftwood Creek, Nebraska.

This is in wide contrast with the prolonged geologic extent attributed to *Mesohippus*, *Miohippus*, *Parahippus*, and *Merychippus*, as well as to *Pliohippus* which is recorded from its first appearance in the Lower Pliocene, Procamelus-Hipparion zone, to the full Middle Pliocene, Glyptotherium zone of Mt. Blanco.

The principal distinction between *Merychippus* and *Protohippus* is that in the latter the milk molars are narrow, subhypsodont, fully cemented, inner basal cusp small or lacking, the permanent teeth with higher crowns.

The characters which are common to the species listed above are:

1. Grinding teeth hypsodont, fully cemented at the time of eruption.
2. Deciduous premolars subhypsodont, fully cemented at time of eruption.
3. Proto- and metaconules crescentic, united with crochet and hypostyle respectively.
4. Protocone round or oval, always united with protoloph.
5. Protocone and hypocone typically symmetrical, sometimes united after wear, protocone sometimes slightly enlarged.
6. Enamel borders of fossettes relatively simple or with primary plications only, *e. g.* pli caballin, pli crochet, pli hypostyle, pli metaloph, etc.
7. Metastylid well separated except at base of crown, where it fuses with metaconid.
8. Lachrymal fossa usually shallow (*P. perditus, P. simus, P. niobrarensis*); no malar fossa.
9. Grinding teeth sharply incurved.
10. Feet anisotridactyl, lateral digits abbreviated, metapodials slender.

The proposed grouping of *Protohippus* by Matthew (1913) is as follows:

Group I	Group II	Group III
Protohippus perditus and closely allied *P. castilli* with *P. parvulus* fairly distinct; *P. pachyops* a larger and more progressive species. Crowns moderately long, grinders curved, protocone well united to protoconule, fossette borders not much complicated, fossettes somewhat contracted. *Protohippus perditus* " *profectus* " *retrusus*	*Protohippus placidus*, with comparatively long-crowned teeth, upper molars nearly straight, protocone oval or lenticulate, slightly though continuously connected with protoloph, fossettes more contracted, grinding teeth narrow. Near the *H. gratum* group of *Hipparion*. *Protohippus proplacidus*	*Protohippus simus*, larger and more specialized derivatives of the typical *P. perditus* group (*P. simus* and *Pliohippus fossulatus*).

I. TYPE DESCRIPTIONS OF THE SPECIES OF PROTOHIPPUS IN CHRONOLOGIC ORDER.

Date	Original name and author	Present reference	Locality	Life zone
1854	*Hippodon speciosus* Leidy	Indeterminate	Bijou Hills, Missouri River, So. Dak.	Zone undetermined
1858	*Equus (Protohippus) perditus* Leidy	*Protohippus perditus*	Fort Niobrara, Nebr.	Procamelus-Hipparion zone
1868	“ *parvulus* Marsh	“ *parvulus*	Antelope Station, Nebr.	Zone undetermined
1869	*Protohippus placidus* Leidy	“ *placidus*	Fort Niobrara, Nebr.	Procamelus-Hipparion zone
1885	“ *castilli* Cope	“ *castilli*	Tehuichila, Vera Cruz, Mex.	Zone undetermined
1889.1	*Hippotherium retrusum* Cope	“ *retrusus*	Driftwood Creek, Nebr.	Pliauchenia-Peraceras zone
1889.2	*P.* or *H. profectus* Cope	“ *profectus*	“ “ “	“ “ “
1893	*Protohippus pachyops* Cope	“ *pachyops*	Donley Co., Texas	Procamelus-Hipparion zone
1906.1	“ *simus* Gidley	“ *simus*	Little White River, Rosebud Agency, So. Dak.	“ “ “
1906.2	*Neohipparion niobrarensis* Gidley	“ *niobrarensis*	Niobrara, Nebr.	“ “ “
1915	*Protohippus tehonensis* Merriam	“ *tehonensis*	Tejon Hills, San Joaquin Valley, Cal.	“ “ “
1918.1	“ *perditus secundus* Osborn	“ *perditus secundus*	Republican River, Driftwood Creek, Nebr.	Pliauchenia-Peraceras “
1918.2	“ *proplacidus* Osborn	“ *proplacidus*	Sand Cañon, Logan Co., Col.	Procamelus-Hipparion “

II. TYPES AS RECORDED OR INFERRED IN 1917 IN GEOLOGIC SUCCESSION.

Date	Species, Present reference	Life zone	Formation, Beds	Locality	Age
1918.1	*Protohippus perditus secundus* Osborn	*Pliauchenia-Peraceras* zone	Republican River beds	Republican River, Driftwood Creek, Nebr.	Lower Pliocene
1889.2	“ *profectus* Cope	“ “ “	“ “ “	Driftwood Creek, Nebr.	“ “
1889.1	“ *retrusus* Cope	“ “ “	“ “ “	“ “ “	“ “
1885	“ *castilli* Cope	Zone undetermined	Shales of Tehuichila	Vera Cruz, Mexico	?Lower “
1918.2	“ *proplacidus* Osborn	Procamelus-Hipparion zone	Upper Pawnee Creek beds	Sand Cañon, Logan Co., Col.	Upper Miocene or Lower Pliocene
1915	“ *tehonensis* Merriam	“ “ “	Chanac formation	Tejon Hills, San Joaquin Valley, Cal.	“ “ “ “ “
1893	“ *pachyops* Cope	“ “ “	Clarendon formation	Donley County, Texas	“ “ “ “ “
1906.1	“ *simus* Gidley	“ “ “	Little White River formation	Rosebud Agency, So. Dak.	“ “ “ “ “
1906.2	“ *niobrarensis* Gidley	“ “ “	Niobrara River “	Fort Niobrara, Nebr.	“ “ “ “ “
1868	“ *parvulus* Marsh	Zone undetermined		Antelope Station, Nebr.	“ “ “ “ “
1869	“ *placidus* Leidy	Procamelus-Hipparion zone	Niobrara River “	Fort Niobrara, Nebr.	“ “ “ “ “
1858	“ *perditus* Leidy	“ “ “	“ “ “	“ “ “	“ “ “ “ “
1854	*Hippodon speciosus* Leidy *gen. et sp. indet. nomen nudum*			Bijou Hills, So. Dak.	

PROCAMELUS-HIPPARION ZONE. 13. LOWER PLIOCENE.

The typical exposures of this great zone along the Niobrara River and the Little White River contain all the leading types of *Protohippus*, *Pliohippus*, and *Hipparion* of Leidy, Marsh, and Gidley. Geographically this zone is one of the most widespread of all the late Tertiaries.

Hippodon speciosus Leidy 1854. *Gen. et spec. indet.*

Text Fig. 101.

Hippodon speciosus, Leidy, Joseph. [Remarks on *Sus americanus*, or *Harlanus americanus*, and on other extinct mammals], *Proc. Acad. Nat. Sci. Phila.* Vol. VII, Pt. III, 1854, p. 90, no figure. "The Extinct Mammalian Fauna of Dakota and Nebraska," *Jour. Acad. Nat. Sci. Phila.* (2) Vol. VII, 1869, pp. 320–321, pl. XIX, type, fig. 23, paratypes, figs. 19–22.

Horizon and locality.— (Leidy) "Bijou Hill, east of the Missouri River, in a tertiary formation surmounting cretaceous beds." Bijou Hills, Brule Co., South Dakota. Type collected by "Meek and Hayden, during an expedition to Nebraska Territory in the summer of 1853." Horizon probably Upper Miocene.

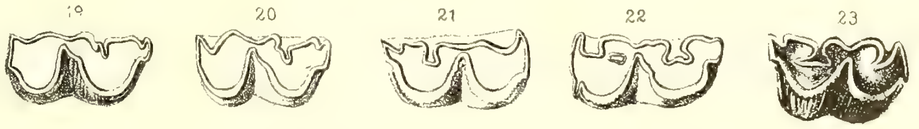


Fig. 101. Original figure of type (fig. 23), Amer. Mus. Hall Coll. 465, and paratypes (figs. 19–22) of *Hippodon speciosus* Leidy, *gen. et sp. indet.* Natural size. After Leidy, 1869, Pl. xix, figs. 19–23.

Type.— Amer. Mus. Hall Coll. 465. A lower molar, either m_1 or m_2 of the right side, lacking the cement, and about half worn. (Leidy, 1854, p. 90) "...an inferior molar of a solipedal animal." Leidy again referred to the type (1869, p. 320) as follows: "The specimen of the last figure is from Bijou Hill, and appeared so peculiar that when first seen it was viewed as indicating a new species, and was described in the Proceedings of the Academy for 1854, p. 90, under the name of *Hippodon speciosus.* The specimens of the former figures [19–22] look so much like the latter as to render it probable that they belonged to the same animal."

Type figure.— Text Fig. 101 of this Memoir.

The genus *Hippodon* and species *H. speciosus* are indeterminate because the type and paratype lower molars figured above show no distinguishing characters. The type certainly does not belong either to *Hipparion* or to *Pliohippus.* Its characters are intermediate between a small *Merychippus* and a small *Protohippus.* In size it slightly exceeds *Protohippus placidus.* The name becomes a *nomen nudum* because both generically and specifically the type is indeterminate.

Protohippus perditus Leidy 1858.

Plates 21.3, 25.8. Text Figs. 102, 103, 116a,

Equus (Protohippus) perditus Leidy, Leidy, Joseph. "Notice of Remains of Extinct Vertebrata, from the Valley of the Niobrara River, collected during the Exploring Expedition of 1857, in Nebraska, under the command of Lieut. G. K. Warren, U. S. Top. Eng., by Dr. F. V. Hayden, Geologist to the Expedition," *Proc. Acad. Nat. Sci. Phila.* Vol. X, 1858 (sig. dated Apr., 1858), pp. 26–27, no figure. *Protohippus perditus*, "The Extinct Mammalian Fauna of Dakota and Nebraska," *Jour. Acad. Nat. Sci. Phila.* (2) Vol. VII, 1869, pp. 275–277, Pl. xvii, figs. 1, 2.

Horizon and locality.— Niobrara River, near Fort Niobrara, Nebraska. Procamelus zone, Nebraska. Lower Pliocene. Type collected by F. V. Hayden, 1857.

Type.— U. S. Nat. Mus. 619, cast Amer. Mus. 10772. (Leidy, 1858.) "...a fragment of an upper jaw containing the posterior four molars." P^4–m^3. Measurements: (Gidley, 1907, p. 882) p^4 a.p. .020, tr. .022, height of crown .036; m^1 a.p. .0195, tr. .0215; m^3 a.p. .020, tr. .0175. *Neotype.* (Gidley, 1907, p. 882) "A nearly complete skull," Amer. Mus. 10838. From the Little White River, near Rosebud Indian Agency, South Dakota.

Type figure.— Text Fig. 102 of this Memoir.

Characters.— (Leidy, 1858) (1) The portion of jaw is like the corresponding part in the recent horse. (2) Molar teeth with their crowns about one-half worn; (3) enamel folds even less complex than in the recent horse; (4) antero-internal fold [protocone] of the same form, direction, and mode of continuation as the posterointernal fold [hypocone]. (Gidley, 1907) (5) Moderately small size. (6) Laterally compressed and backwardly directed protocone and hypocone of the upper molars. (7) Shallow, not sharply defined lachrymal fossa; (8) rudimentary condition or entire absence of malar fossa.

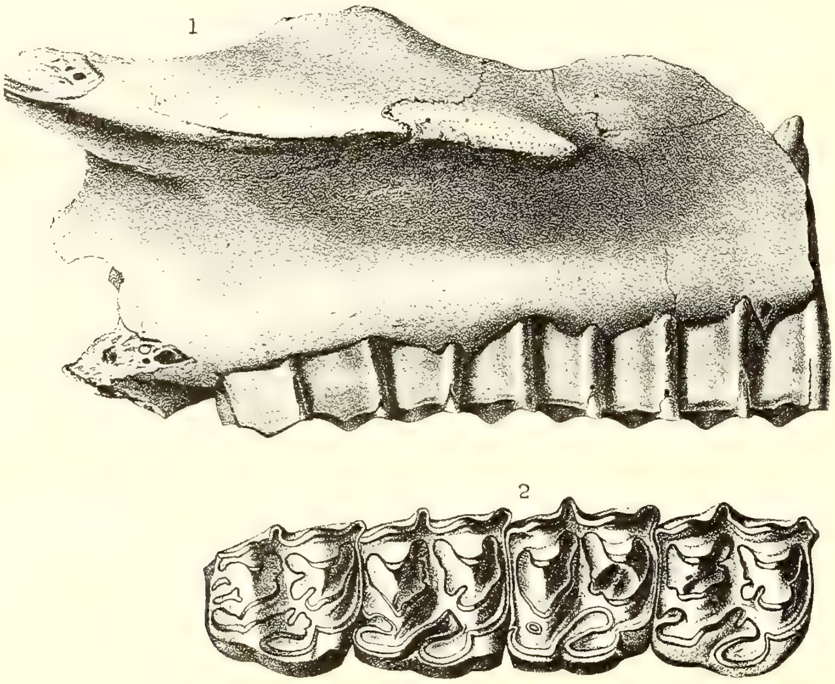


Fig. 102. Original figures of the type of *Protohippus perditus* Leidy, U. S. Nat. Mus. 619. After Leidy, 1869, Pl. xvii, figs. 1, 2. Natural size.

The specimen selected by Gidley as the neotype (Amer. Mus. 10838) does not clearly exhibit in its molar teeth the characteristic specific features enumerated by Leidy.

Protohippus parvulus Marsh 1868.

Text Figs. 104, 105.

Equus parvulus, Marsh, O. C. "Notice of a New and diminutive species of fossil Horse (Equus parvulus), from the Tertiary of Nebraska," *Amer. Jour. Sci. and Arts* (2) Vol. XLVI, No. 138, Nov. 1868, p. 374–375, no figure.[1]

Horizon and locality. (Marsh) "Antelope station on the Union Pacific Railroad, about 450 miles west of Omaha.... during the excavation of a well....at a depth of sixty-eight feet." Type collected by O. C. Marsh, 1868.[1]

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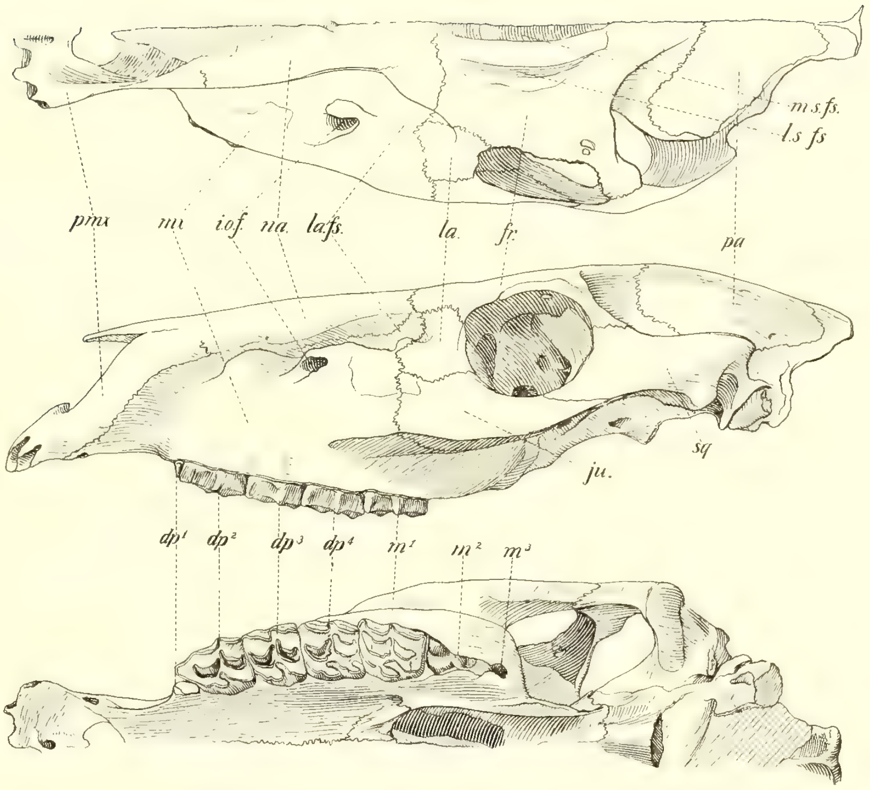
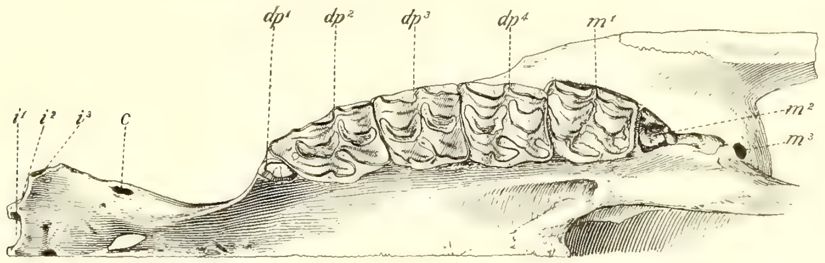
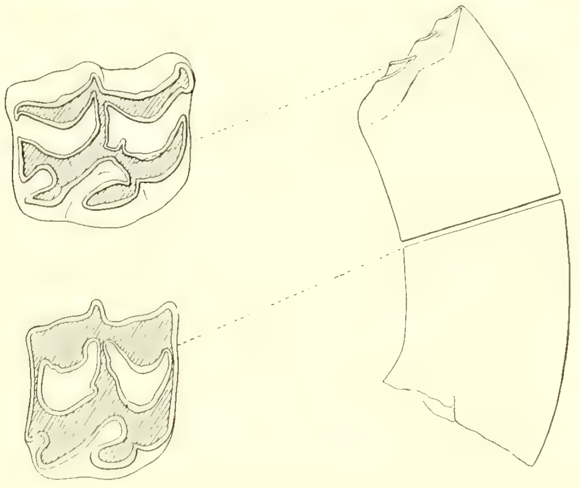
[1] Professor Marsh gave an account of this locality and its fossils before the National Academy of Sciences at the Northampton meeting, August, 1868. *Op. cit.* p. 374.



Top, side, and palatal views of skull. One-third natural size. Fig. 3, p. 137.



Palatal view of left half of skull. One-half natural size. Fig. 5, p. 138.



Crown and sectional views of first true molar, m^2. Natural size. Fig. 4, p. 138.

Fig. 103. Original figures of "hypotype" (Gidley) of *Protohippus perditus* Leidy, Am. Mus. 10838, immature. After Gidley, 1906.

Type.— (Marsh, 1868, p. 375) "The equine remains now to be noticed consist mainly of bones of the limbs, and among them is a hoof-phalanx, a coronary or second phalanx, parts of the first phalanx and metacarpals, as well as some of the smaller carpal and tarsal bones, and fragments, apparently from other parts of the skeleton." (Lull, letter Oct. 23, 1915) "Type consists of several individuals bearing the numbers 11340 to 11345. From Antelope Station, Nebraska, marked Pliocene. . . . first fossil material Professor Marsh ever collected." *Neotype.* The upper tooth (Text Fig. 107), referred to by Marsh in his second description[1] of this animal in 1874, may be regarded as a neotype (*P. parvulus*, Yale Mus. 11342). It is doubtfully referable to the genus *Protohippus.*

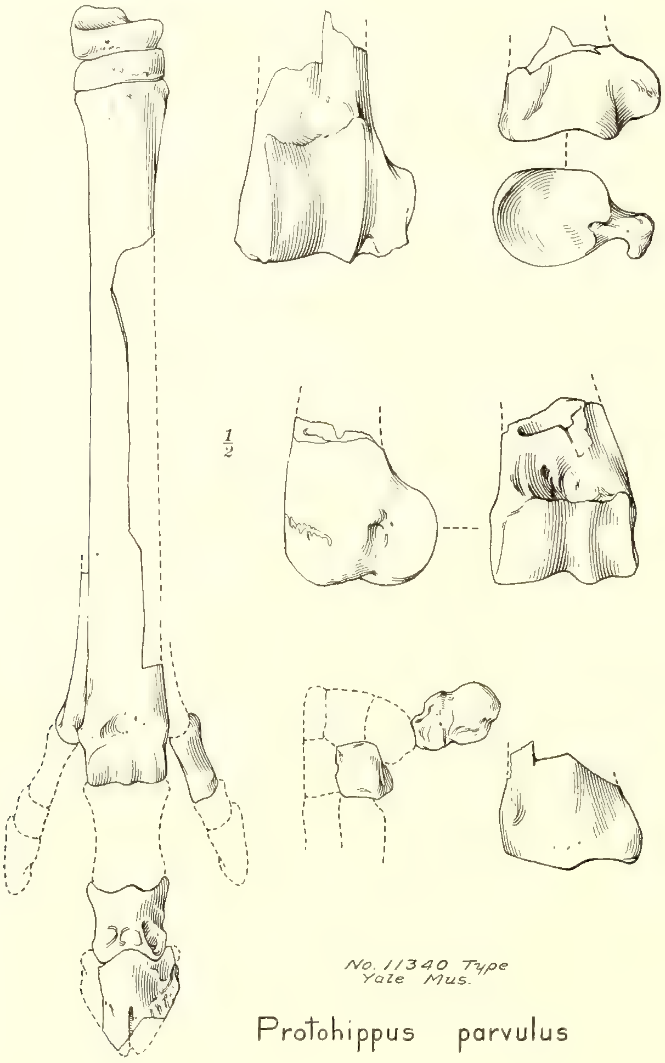


Fig. 104. *Protohippus (Equus) parvulus* Marsh, Yale Mus. 11340–11341. Right pes, anterior view of femur, scapula, humerus, radius of the type, two individuals mixed. Portion of left carpus restored. One-half natural size.

Type figure.— Text Fig. 104 of this Memoir.

Lull (letter, Dec. 10, 1915) remarks as regards the description of 1868 by Marsh: "In Marsh's original description he says nothing of any teeth, in fact, he implies that no teeth were present, because he says: 'Additional parts of the skeleton, especially the teeth, would perhaps show generic characters differing from those of the living horse.' In his description of *P. parvulus* in 1874, Marsh says: 'With the limb bones preserved an upper tooth was found which doubtless pertained to the same animal, although it is rather larger in proportion.' There is no trace of this tooth with the original material."

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[1] "Notice of New Equine Mammals from the Tertiary Formation," *Amer. Jour. of Science and Arts,* (3) Vol. VII, 1874, pp. 247–258 (251–253).

Characters.— (Matthew, 1913) As shown in the accompanying figures of the type specimen, the pes is generically indeterminate; it belongs either to *Protohippus* or to *Hipparion*, probably to the former genus. The type includes a Mts. III of moderate length, approximately lacking the lateral facet for the cuneiform (a facet typically present in *Pliohippus*); the lateral metatarsals are rather heavy; the hoofs are of medium width; the navicular is low and broad; the ulna is coalesced suturally with the radius at the distal end, apparently also along the shaft. (Osborn, 1918) The discovery by Troxell (1916) of the pes of *Protohippus* (see Fig. 116a) tends to confirm the reference of this type to *Protohippus*, as a species not remote in size from the type of *P. placidus* Leidy.

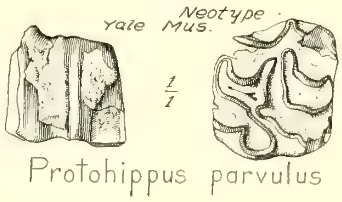

Fig. 105. Neotype half worn upper molar found with the type skeletal fragments of *Protohippus* (*Equus*) *parvulus*, Marsh, Yale Mus. 11342, now considered referable to the same species and possibly to the same individual as the type.

Protohippus placidus Leidy 1869.

Plate 34.4. Text Figs. 106, 107, 116a.

Protohippus placidus, Leidy, Joseph. "The Extinct Mammalian Fauna of Dakota and Nebraska," *Jour. Acad. Nat. Sci. Phila.* 1869 (2) Vol. VII, pp. 277–279, 463, Pl. xviii, type fig. 40, paratypes, figs. 39, 41–48.

Horizon and locality.— Niobrara River, near Fort Niobrara, Nebraska, Procamelus zone, Nebraska, Lower Pliocene.

Type.— U. S. Nat. Mus. 621. (Gidley, 1907, p. 887) "A left upper premolar, p^2." (Leidy, 1869) "The specimens

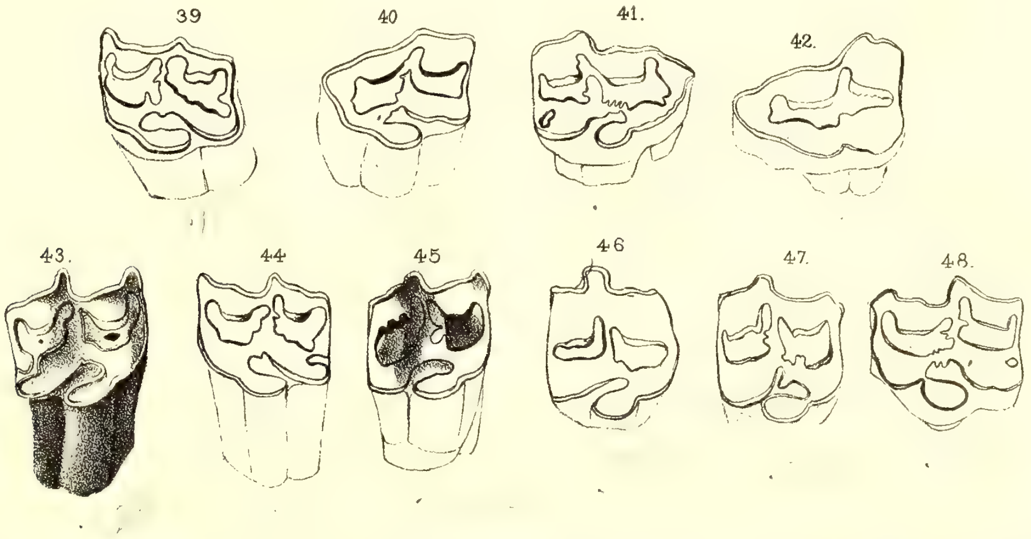

Fig. 106. Original figures of the type of *Protohippus placidus* Leidy, U. S. Nat. Mus. 621 p^2 (40), and of the paratypes (39, 41–48). Natural size. After Leidy, 1869, Pl. xviii.

apparently referable to it [*Protohippus placidus*] are as follows: 1. A first upper molar tooth [p^2] about half worn away. The masticating surface, represented in figure 40, plate XVIII, presents extreme simplicity in the arrangement of the enamel, compared with its condition generally in equine animals." This tooth [fig. 40] is the type. Measurements: (Gidley, 1907) p^2 a.p. .0185, tr. .016. (Leidy) Height of crown external 9 to 10 lines. The other specimens, figs. 39, 41–48, are *paratypes,* there being no evidence in Leidy's description that these isolated molars were collected from the same locality. The species thus rests on the very uncertain evidence afforded by the type second upper premolar (fig. 40). *Neotype.*— (Gidley, 1907) Amer. Mus. 10830, a right maxilla, containing p^1–m^3, also other upper and lower jaws, referred, from the Big Spring Cañon and the Little White River exposures of South Dakota. Gidley (1906, p. 141) does not specify Amer. Mus. 10830 as a neotype, but gives a clear and full definition of the species from this new material, first mentioning the maxilla, Amer. Mus. 10830, but including upper jaws Amer. Mus. 9830, 10826, 10843, and lower jaws 10849, 10850a, 10853, 10855, 10857.

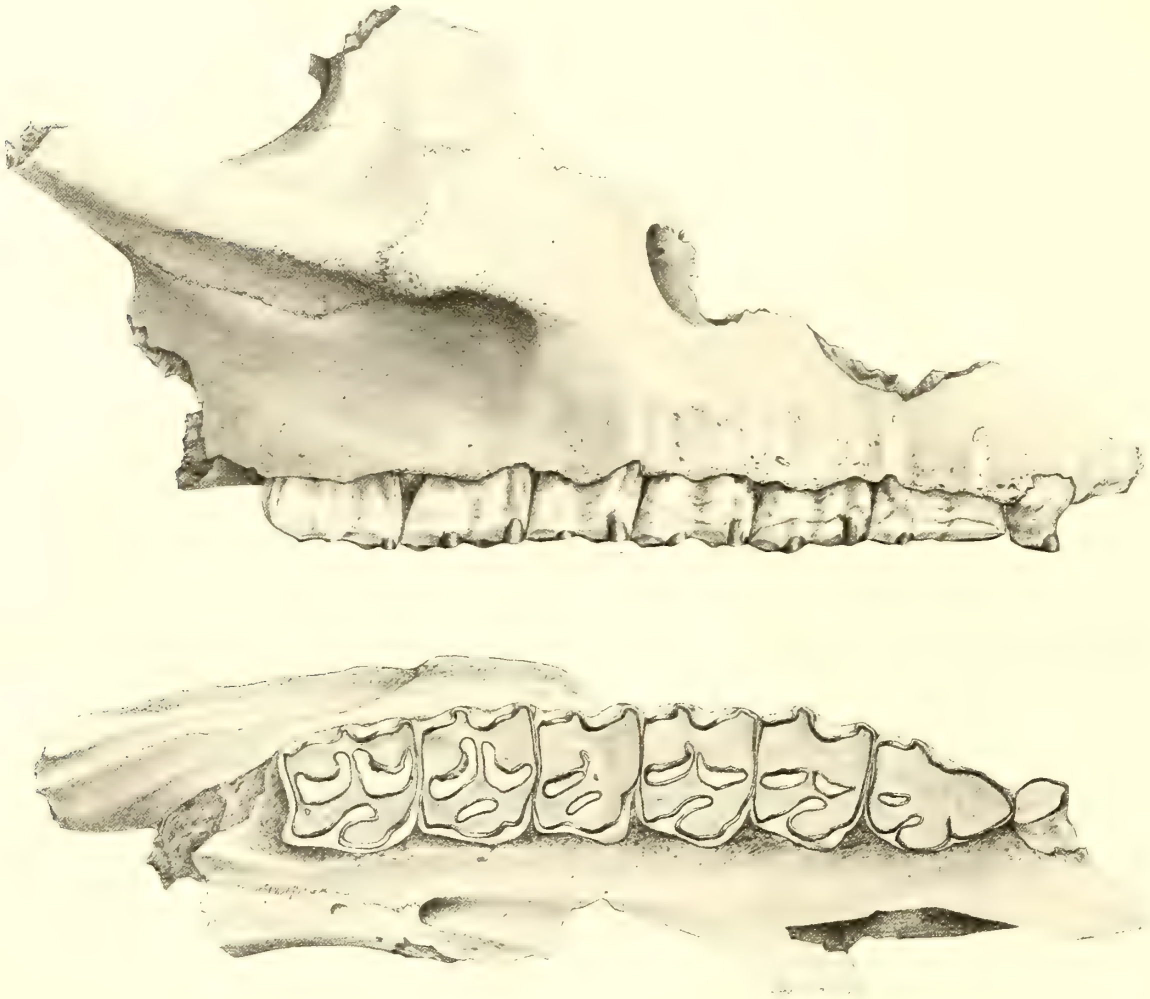

Fig. 107. Neotype (Gidley) of *Protohippus placidus* Leidy, Amer. Mus. 10830. Portion of right maxilla with grinding teeth, p^1–m^3, side and crown views. One-half natural size. Drawing by B. Yoshihara.

Type figure.— Text Fig. 106 of this Memoir.

Characters.— (Leidy, 1869) (1) Separated from *P. perditus* as an animal of small size. (2) Enamel plications in the type and some of the paratypes relatively simple; (3) crowns less curved than in *P. perditus*; (4) central lakes [fossettes] wide and gaping.

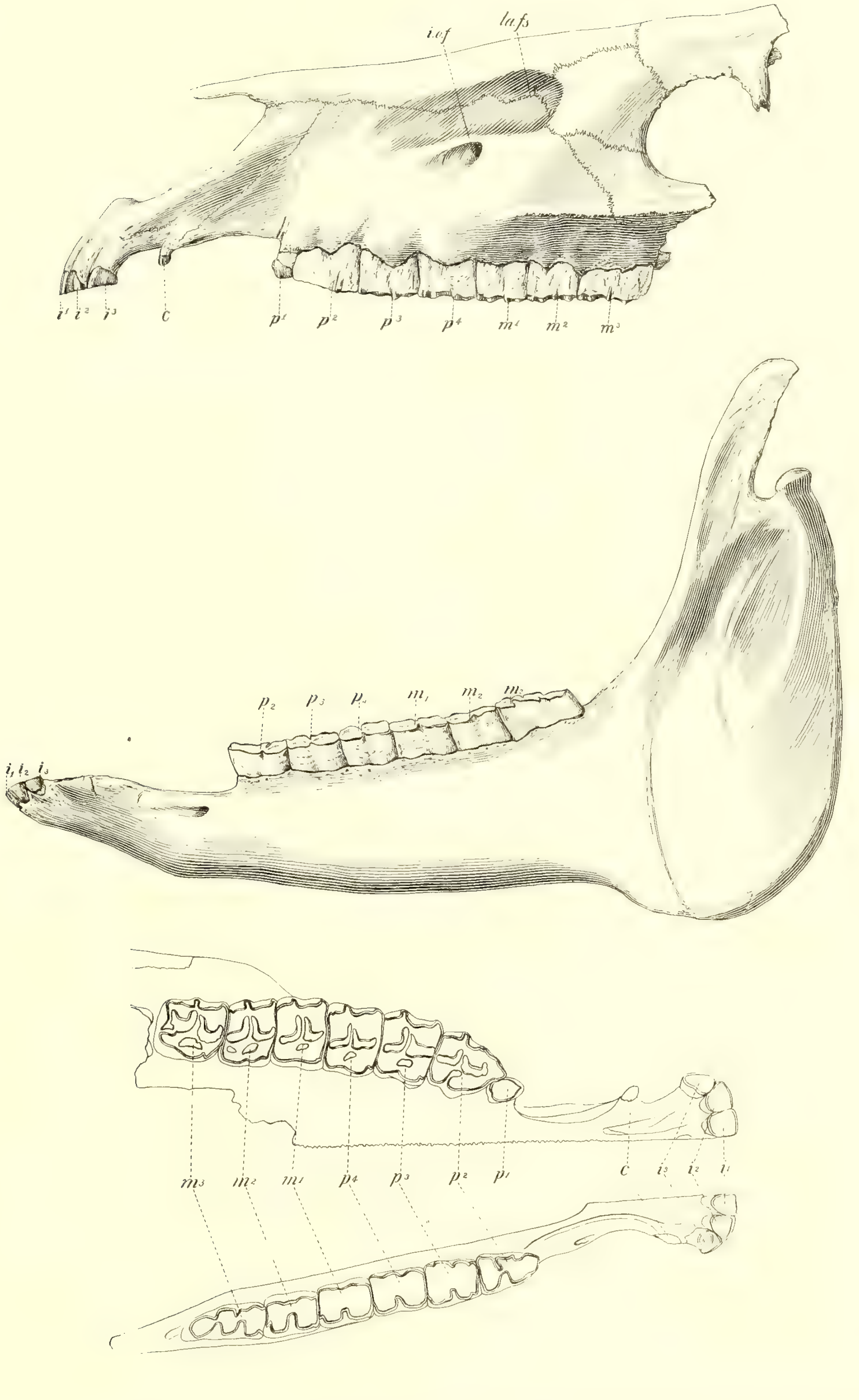

Fig. 108. (Upper) Original figure of anterior part of skull of the type of *Protohippus niobrarensis* Gidley, Amer. Mus. 10828. *i. o. f.*, infraorbital foramen; *la. fs.*, lachrymal fossa. One-half natural size. After Gidley, 1906, fig. 18, p. 151. (Middle) Original figure of lower jaw of the type, external view. One-half natural size. After Gidley, fig. 19, p. 152. (Lower) Original figure of upper and lower dentition of the type. One-half natural size. After Gidley, 1906, fig. 20, p. 153.

Neotype characters.— (Gidley, 1906, 1907) Based on fragment of skull, Amer. Mus. 10830. (1) Protocones directed well backward, as in *P. perditus;* (2) enamel borders of fossettes relatively simple; (3) upper molariform teeth of smaller size than in *P. perditus, i. e.* diameters of crown; (4) of greater comparative length than *P. perditus;* (5) of less curvature than *P. perditus;* (6) fossettes in true molars of less transverse width. (7) A slight depression in the malar bone immediately in front of the orbit, otherwise the facial region full and smooth as in *P. perditus;* (8) the lachrymal fossa shallow and not sharply defined.

This species obviously rests upon the redefinition by Gidley through the neotype. Gidley observes (Matthew & Gidley, 1906, p. 141, Gidley, 1907, p. 887) that in the comparative length and relatively slight curvature of the tooth crowns and the general form of the fossettes the grinding teeth resemble *Hipparion* (*Neohipparion*) rather than *Protohippus* yet the protocone and hypocone structure are related to *Protohippus*. Measurements of neotype, upper jaw Amer. Mus. 10830: total length molar-premolar series, p^2–m^3, 102; p^4 a.p. .015, tr. .0183; m^1 a.p. .0132, tr. .017.

The animal is relatively abundant in the Nebraska formation and several well preserved specimens from Big Spring Cañon and the little White River are referred to it.

The comparatively long-crowned teeth and nearly straight upper molars with their less rounded fossettes resemble rather the teeth of *Hipparion gratum* (Leidy) than they do those of *Protohippus perditus*. The hitherto unknown foot characters (Fig. 116a) are revealed in a referred specimen recently found by Troxell near Mission, South Dakota. The manus is anisotridactyl, with a slender, laterally compressed median metatarsal. It resembles *Merychippus* rather than *Pliohippus*.

Protohippus niobrarensis Gidley 1906.

Plate 21.2. Text Fig. 108.

Neohipparion niobrarense Gidley, Matthew, W. D., and Gidley, J. W. "New or Little Known Mammals from the Miocene of South Dakota," *Bull. Amer. Mus. Nat. Hist.* Vol. XXII, Art. VIII, May 26, 1906, p. 151, figs. 18, 19, 20.

Horizon and locality.— Near Ft. Niobrara, Niobrara River, Nebraska, Procamelus-Hipparion zone, Nebraska, Lower Pliocene. Type collected by J. W. Gidley, American Museum Expedition of 1903.

Type.— Amer. Mus. 10828, anterior portion of skull with lower jaws (Gidley, 1907) "The type specimen is of a very old individual with the tooth characters practically obliterated by wear. The skull and jaw characters, therefore, form the basis of its generic reference." Measurements: molar-premolar series, p^1–m^3, .117; p^4 a.p. .017, tr. .0215; m^1 a.p. .0165, tr. .0205.

Type figure.— Text Fig. 108 of this Memoir.

Characters.— (Gidley, 1906, p. 152, 1907, p. 927) Gidley separates this species from *Hipparion* (*Neohipparion*) *gratum* as follows: (1) The skull, especially in the nasal and premaxillary region, is longer and narrower; (2) the palate is narrow and more arched; (3) the anterior palatine foramina are more open but do not extend as far backward as in *H. gratum;* the posterior palatal notch apparently extends as far forward as the middle of m^1; (4) the malar fossa is wanting; (5) the lachrymal fossa is larger, extends farther backward, and has a rather sharply defined posterior border; (6) the symphysis of the lower jaw is longer and narrower than in *H. gratum* but is not so extreme in proportions as in *H. dolichops;* and (7) the ramus is bowed as in *H. gratum* but has a less vertical depth.

Protohippus simus Gidley 1906.

Plates 21.1, 22.2. Text Fig. 109.

Protohippus simus sp. nov., Matthew, W. D., and Gidley, J. W. "New or Little Known Mammals from the Miocene of South Dakota," *Bull. Amer. Mus. Nat. Hist.* Vol. XXII, Art. VIII, May 26, 1906, p. 139, no figure.

Horizon and locality.— Little White River, near the Rosebud Indian Agency, South Dakota, Lower Pliocene. Procamelus-Hipparion zone. Type collected by American Museum Expedition of 1902.

Type.— Amer. Mus. 9820, anterior portion of adult skull with nearly complete dentition. Measurements: molar-

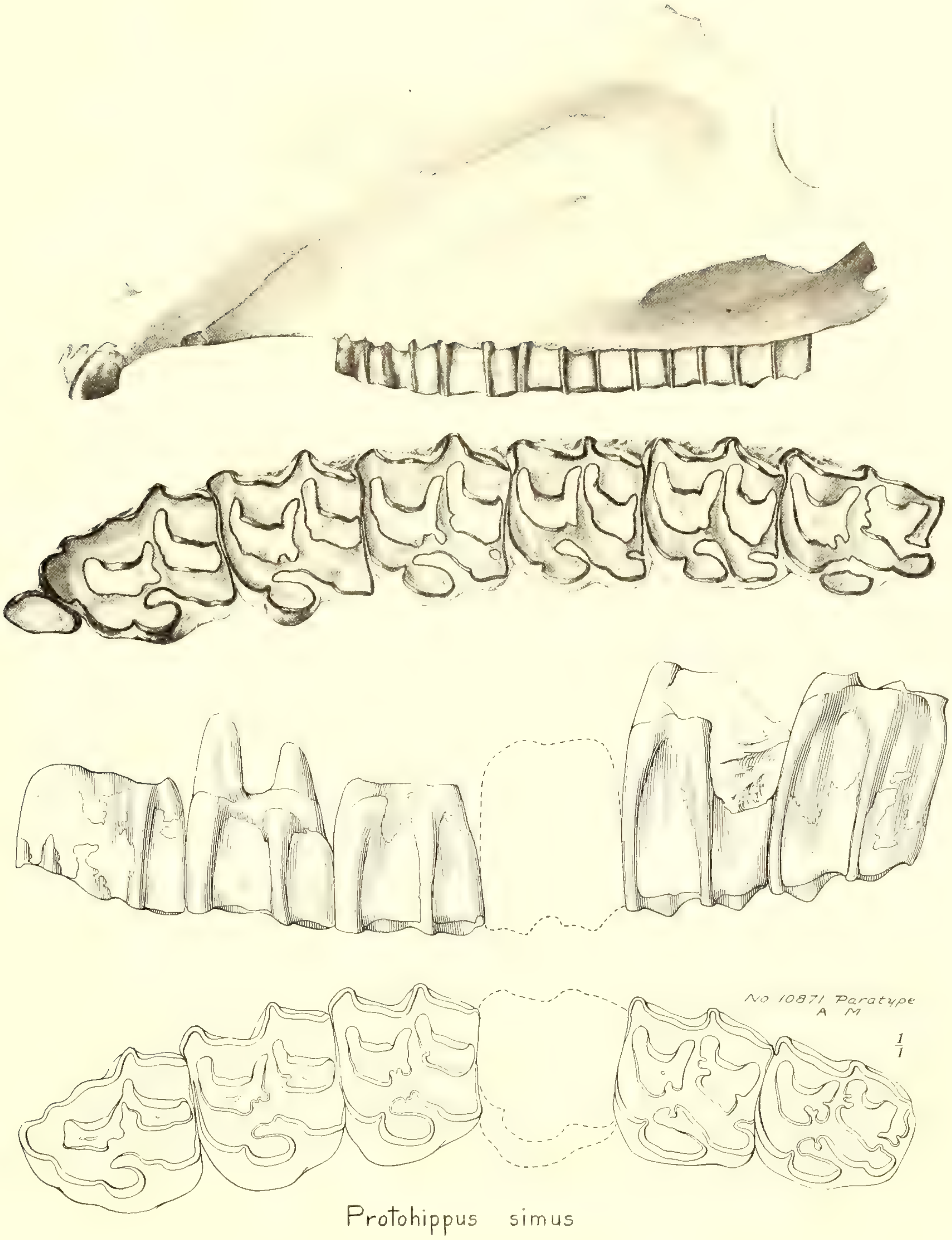

Fig. 109. (Upper) Type of *Protohippus simus* Gidley, Amer. Mus. 9820. Lateral view of skull, crown view of superior grinding series of the right side. Drawings by B. Yoshihara. (Lower) *Protohippus simus* Gidley, Amer. Mus. 10871, superior grinding teeth of the paratype, of the left side. Skull one-half natural size, teeth natural size.

premolar series, p^2–m^3, .135; molar series .062; m^1, a.p. .020, tr. .023; p^4 a.p. .021, tr. .0245. *Paratype.* Am. Mus. 10871. (Gidley, 1907, p. 925) A portion of an upper jaw containing all the large cheek teeth except m^1.

Type figure.— Plate 21.1, text Fig. 109 of this Memoir.

Characters.— (Gidley, 1907, p. 925) (1) Allied to *Protohippus perditus* though somewhat larger and differing in the following characters: (2) protocones of a more progressive stage in their fuller development anteriorly, thus forming a deeper infolding of the enamel between them and the protoconules; (3) fossettes narrower transversely than in *P. perditus;* (4) preorbital or facial region relatively shorter and broader than in *P. perditus;* (5) incisive border but little curved, giving the muzzle a rather truncate appearance; (6) palate broader and less arched than in *P. perditus,* especially in front of premolars; (7) malar fossa wanting, as in *P. perditus;* (8) lachrymal fossa broader, much more shallow, and less sharply defined than in *P. perditus;* (9) comparative great vertical depth of skull may be due in part to distortion. (Osborn, 1918) (10) Protocone strongly constricted and separated at the summit from protoconule; (11) evidence of a small pli caballin, of one crochet enamel fold in prefossette, and of two enamel folds in postfossette.

Protohippus pachyops Cope 1893.

Plates 23.1,1a,2, 24.2,2a. Text Fig. 110.

Protohippus pachyops Cope, Cope, E. D. Name and figure, no description, "On the Permanent and Temporary Dentitions of Certain Three-toed Horses," *Amer. Naturalist,* Vol. XXVI, Nov., 1892, pp. 943, 944, pl. XXVI, fig. 1. "A Preliminary Report on the Vertebrate Palæontology of the Llano Estacado," *Fourth Ann. Rept. Geol. Surv. Texas,* (1892) 1893, pp. 26–29, Pl. iii, fig. 1, Pl. ix, figs. 2, 3.

Horizon and locality.— (Cope) "Found by myself in the Loup Fork bed of Donley county, Texas." Clarendon formation, Procamelus zone, Lower Pliocene.

Type.— Geol. Surv. Texas Coll. (cast Am. Mus. 14394). (Cope) "Represented by a cranium with lower jaw, from which have been broken away all posterior to the orbits, and all anterior to the second premolars." (Gidley, 1907, p. 913). "But a more careful examination of the type shows it to be that of a colt still retaining the milk molars, with the first true molar just coming into use and the second just protruding from the alveolus, the third not yet having made its appearance." Measurements: (Cope) length of skull as preserved .290; m^1 a.p. .028, tr. .025.

Type figure.— Text Fig. 110 of this Memoir.

Characters.— (Cope) (1) Malar-maxillary ridge obtusely rounded; (2) no preorbital fossa, an oval maxillo-nasal fossa which is strongly pronounced; (3) infraorbital foramen issuing above middle of m^1; (4) the deciduous premolar crowns with protocone section greater longitudinally than transversely, junction with protoconule complete; (5) two enamel folds in prefossette; (6) superior molars with elongate crowns, well curved transversely; (7) inferior with paraconid and hypostylid well developed.

Gidley observes (1907, p. 913) that (1) Cope's conclusions were based on a misconception of the age of the specimen; (2) that the characters of the type are in general those of *Protohippus* but differ in several important details from any previously described species; (3) that the young skull referred to this species by Cope agrees closely with that of [?] *Protohippus affinis.*

Protohippus tehonensis Merriam 1915.

Text Fig. 111.

Protohippus tehonensis, n. sp., Merriam, John C. "New Horses from the Miocene and Pliocene of California," *Univ. Cal. Publ. Bull. Dept. Geol.* Vol. 9, No. 4, Nov. 22, 1915, p. 52, figs. 4a, 4b, 4c.

Horizon and locality.— From the Tejon Hills, southern end of San Joaquin Valley, California. Type collected by J. P. Buwalda.

Type.— Univ. Cal. Pal. Coll. 21779. A first or second superior molar of the left side. Measurements: (Merriam) m^1 a.p. .0225, tr. .0237.

Type figure.— Text Fig. 111 of this Memoir.

Characters.— (Merriam, 1915, Osborn, 1918) (1) Protocone and hypocone in the same longitudinal plane; (2) from the crochet region a *pli caballin,* a prominent crochet fold projecting into the prefossette; (3) a prominent fold projecting into the postfossette; (4) pre- and postfossettes triangular in form.

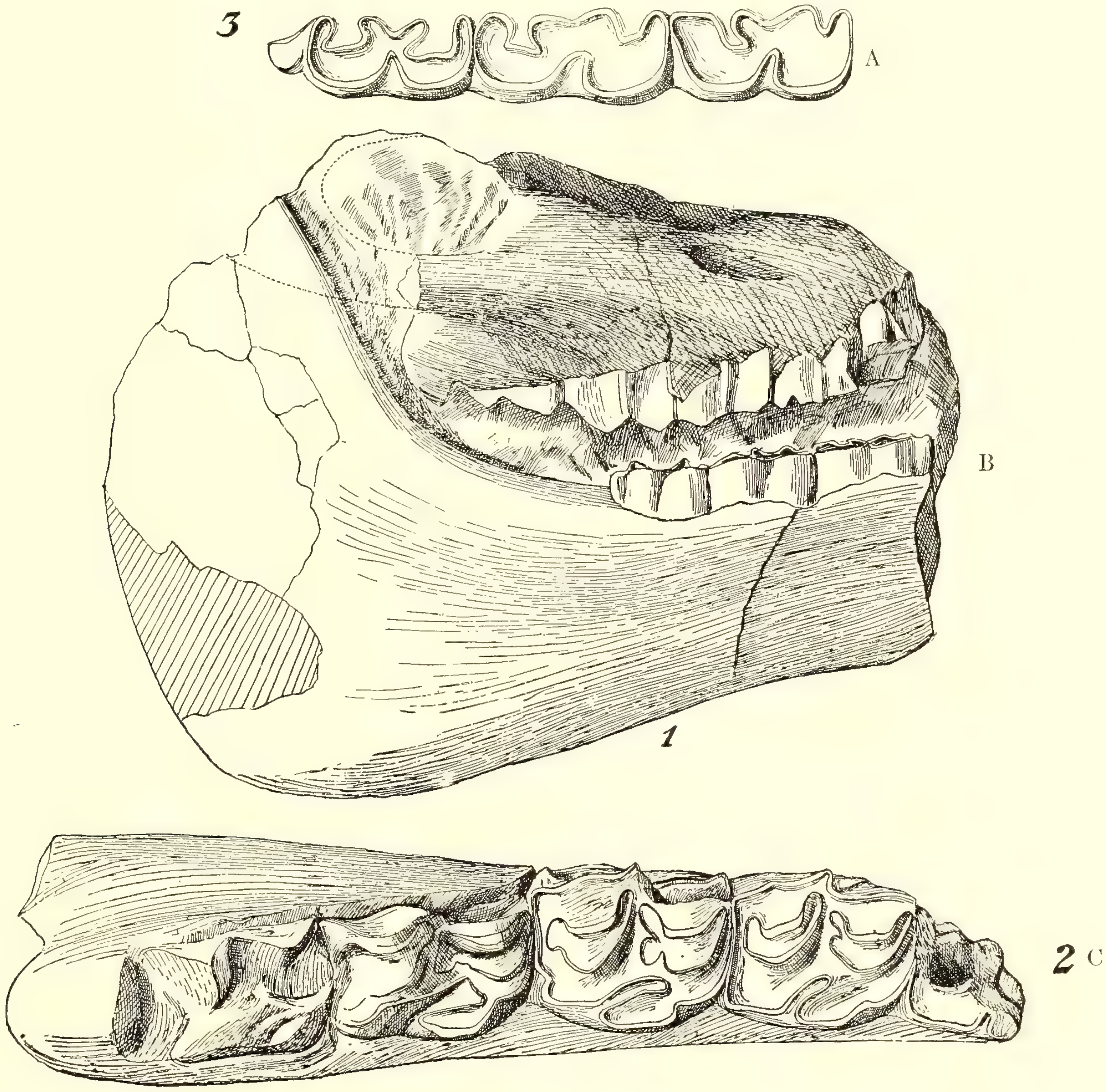

Fig. 110. Original figures of the juvenile type of *Protohippus pachyops* Cope, Geol. Surv. Texas Coll. (cast Amer. Mus. 14394). After Cope, (1892) 1893. (A) Crown view of inferior molars, Pl. ix, fig. 3. Natural size. (B) Side view of portion of the skull, Pl. iii, fig. 1. One-half natural size. (C) Crown view of superior milk molars, Pl. ix, fig. 2. Natural size.

Protohippus proplacidus sp. nov.

Plates 25.7, 34.3. Text Fig. 112.

Horizon and locality.— Sand Cañon, head of Pawnee Creek, Logan County, Colorado, Upper Pawnee Creek beds, Procamelus-Hipparion zone, Lower Pliocene. Type collected by Barnum Brown of the American Museum expedition of 1898. Paratypes also from Sand Cañon.

Type.— Amer. Mus. 9115b. Upper and lower jaws of a young individual with milk dentition, m$\frac{1}{1}$, preformed, and a few fragments of the skeleton.

Paratypes.— Amer. Mus. 9036, 9037, 9038, also probably from Sand Cañon, Pawnee Creek beds, Col.

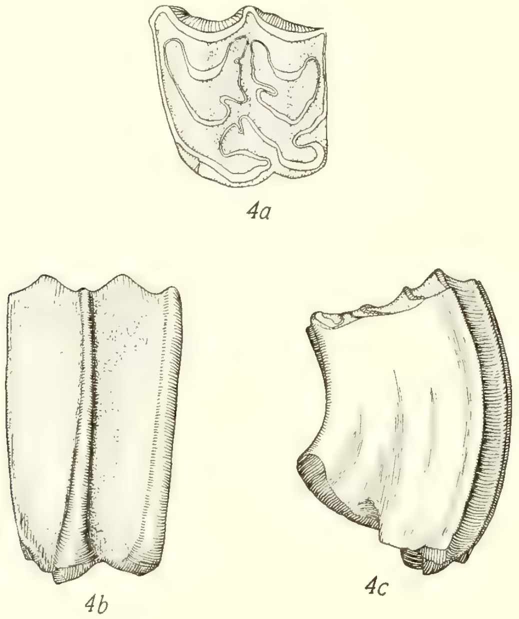

Fig. 111. Original figures of the type of *Protohippus tehonesis,* Merriam, Univ. Cal. Pal. Coll. 21779, ?m^1. *4a* Occlusal view, *4b* outer view, *4c* posterior view. Natural size. After Merriam, 1915, p. 52.

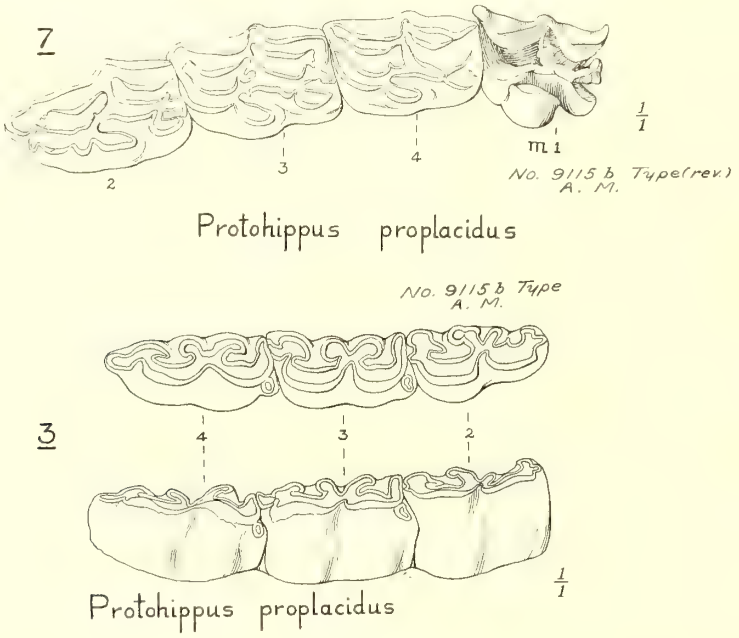

Fig. 112. *Protohippus proplacidus* Osborn, Amer. Mus. 9115b. (7) Superior deciduous teeth of the type, dp$^{2-4}$, and first molar, m^1. Reversed in drawing. (3) Deciduous inferior teeth of the type, dp$_{2-4}$. All figures natural size.

Type figure.— Plate 25.7, text Fig. 112 of this Memoir.

Characters.— (Matthew, 1913) from the type and paratypes. (1) Protocone united with protoconule near summit of crown but not strongly united until near the base of the crown; (2) protocone of flattened oval shape; (3) fossette borders simple, fossettes contracted, prefossettes closed early in wear; (4) pli caballin rudimentary; (5) metastylid not separated from metaconid on p_2; (6) metaconid-metastylid pillars forming a column narrow at top, broader toward base, separated by a shallow groove, deepening toward base but disappearing before it reaches the base; (7) heel of m_3 small, simple, (8) anterior cingulum prominent on inside and outside of tooth, extending to top of crown as in *Hipparion*. (9) Malar fossa apparently absent; (10) metatarsals long, slender, lateral digits much reduced; (11) ungual phalanges rather narrow.

The milk molars are hypsodont, narrow, fully cemented when little worn, removing this type from *Merychippus* and placing it within *Protohippus*. No milk molars of this type are found in the typical Pawnee Creek beds of the Middle Eocene.

Protohippus castilli Cope 1885.

Text Fig. 113.

Protohippus castilli, sp. nov., Cope, E. D. "Report on the Coal Deposits near Lacualtipan, in the State of Hidalgo, Mexico," *Proc. Amer. Philos. Soc.* Vol. XXIII, 1886 (sig. dated Dec. 2, 1885), pp. 150–151, fig. 2. "Pliocene Horses of Southwestern Texas," *Amer. Naturalist*, Vol. XIX, No. 12, Dec., 1885, pp. 1208–1209, Pl. xxxvii, fig. 6.

Horizon and locality.— (Cope, *Proc.* 1885, p. 150) "From the Loup Fork Shales of Tehuichila, Vera Cruz,"... [p. 147] Upper Miocene, of Loup Fork age. Type collected by Edward D. Cope. Freudenberg calls this horizon "Upper Miocene or Lower Pliocene." It contains also *Hyænarctos* recorded from Pliocene of Florida, Oregon and Nebraska.— W. D. M.

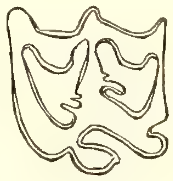

Fig. 2.

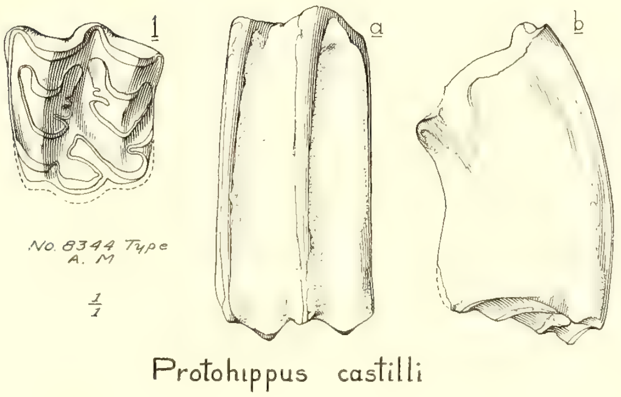

Fig. 113. Type of *Protohippus castilli* Cope, Amer. Mus. Cope Coll. 8344. (Upper) Original figure of the type. After Cope, 1885, fig. 2, p. 151. (Lower) (1) Crown, (a) external, and (b) anterior views of the type, drawn under the direction of Osborn. All figures natural size.

Type.— Amer. Mus. Cope Coll. 8344. (Cope, *Proc.* 1885, p. 150) "This horse is represented by a superior molar tooth of a larger animal than the species last described [*H. peninsulatus*], and one only a little smaller than the zebra." (Gidley, 1907, p. 901) "An upper molar of the left side." Measurements: (Cope) length of crown .040, a.p. .021, tr. .023.

Type figure.— Text Fig. 113 of this Memoir.

Characters.— (Cope, 1885, Osborn, 1917) (1) Of larger size than the type of *Hipparion peninsulatum;* (2) protocone larger and more prominent than hypocone, connected with protoconule and metaconule respectively; (3) crown of molar of medium length, strongly curved inward; (4) grinding surface a little wider than long; (5) fossettes subtriangular, strongly convex inward, each with one large and one smaller enamel fold; (6) external styles prominent.

PLIAUCHENIA-PERACERAS-PLIOHIPPUS NOBILIS ZONE. 14. LOWER PLIOCENE.

TYPICALLY EXPOSED ON THE REPUBLICAN RIVER, WESTERN KANSAS.

Protohippus retrusus Cope 1889.

Text Fig. 114.

Hippotherium retrusum Cope, Cope, Edw. D. "A Review of the North American Species of Hippotherium," *Proc. Amer. Philos. Soc.*, Vol. XXVI, 1889 (sig. dated June 5, 1889), p. 446, figs. 7, 7a, 8.

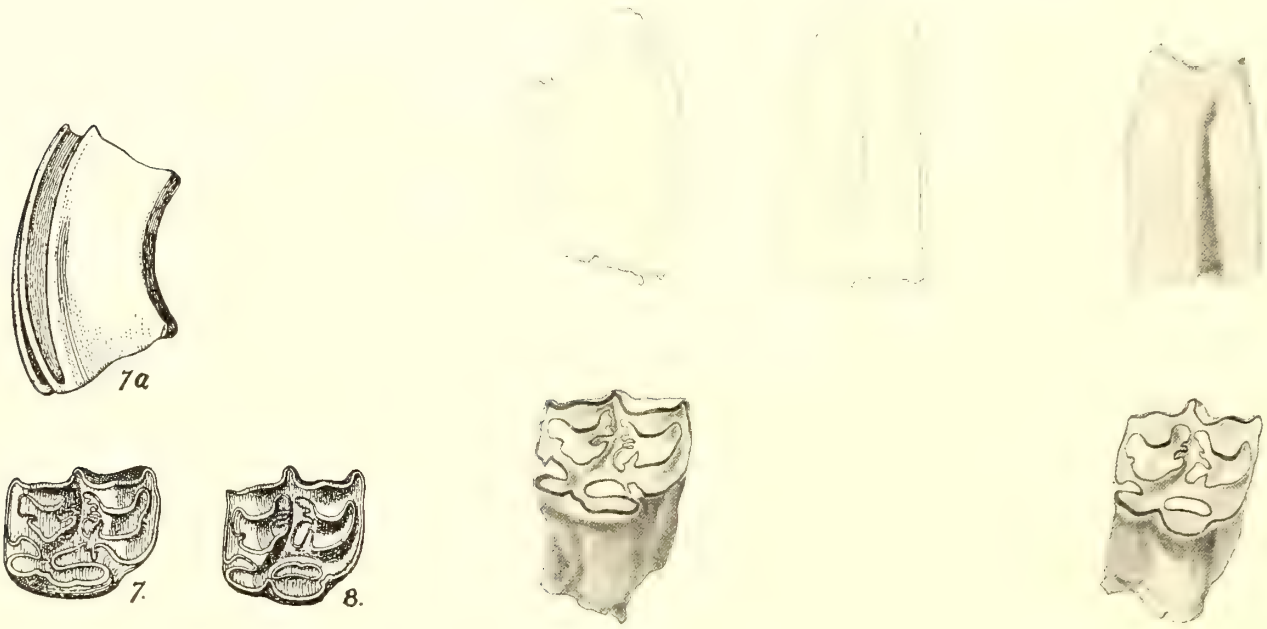

Fig. 114. Type and paratype of *Protohippus retrusus* Cope. (7, *7a*, 8) Original type figures, Amer. Mus. Cope Coll. 8350; (7, 8) crown view of m$^{1-2}$, (7, *7a*) crown and interior views of m^1 (inverted). After Cope, 1889. (Three middle figures) Crown, external, and anterior views of the type tooth (No. 8350), and (extreme right figures) crown and external views of the more worn paratype tooth, redrawn by S. Oka. All figures natural size.

Horizon and locality.— (Cope, 1889, p. 447) "From Phillips county, Kansas, from the Loup Fork bed." Probably Republican River formation, Peraceras zone, late Miocene or early Pliocene. Type collected by Frank Hazard.

Type.— Amer. Mus. Cope Coll. 8350. (Gidley, 1907) "Two upper molars." (Cope.) "This species is represented in my collection by eight molars, two from one and six from another animal. These are associated with two superior molars with somewhat different characters, which are intermediate between those of *H. gratum* and *H. speciosum*. All were found in the same locality, but separated from their positions in the skull. The two molars [type] first above mentioned are about half worn, and present the characters of the species best." Measurements: (Cope) m^1 a. p. .019, tr. .0185, height of crown .026; m^2 a. p. .020, tr. .018, height of crown, .036.

Type figure.— Text Fig. 114 of this Memoir.

Characters.— (Matthew, 1913, Osborn, 1918) (1) Molar size intermediate, somewhat larger than in *P. placidus* but apparently with shorter crowns; (2) crowns strongly curved; (3) protocone separate from protoloph in m^2, united in m^1; (4) protocone and hypocone united by longitudinal isthmus; (5) protocone flattened oval, posterior in position; (6) pli caballin fold present on little worn teeth, absent on half worn teeth; (7) two folds and minor accessory folds on each side of metaloph projecting into pre- and postfossettes; (8) a single inferior fold (crochet) in prefossette; (9) parastyle narrow, mesostyle broad at base and narrowing rather slightly toward crown.

(Matthew, 1913) "These two type teeth cannot go together as placed; they may not belong to the same animal; the right hand tooth (A) might be *Merychippus;* the left hand tooth, if normal, does not agree well with any of the genera. If normal it represents an undescribed genus on the criteria used to separate the Miocene and Pliocene genera. If placed in *Protohippus* it should be in quotes."

Protohippus profectus Cope 1889.

Plate 22.3. Text Fig. 115.

P. or *H. profectus*, Cope, Edw. D. "A Review of the North American Species of Hippotherium," *Proc. Amer. Philos. Soc.*, Vol. XXVI, 1889 (sig. dated June 5, 1889), pp. 446–447, no figure.

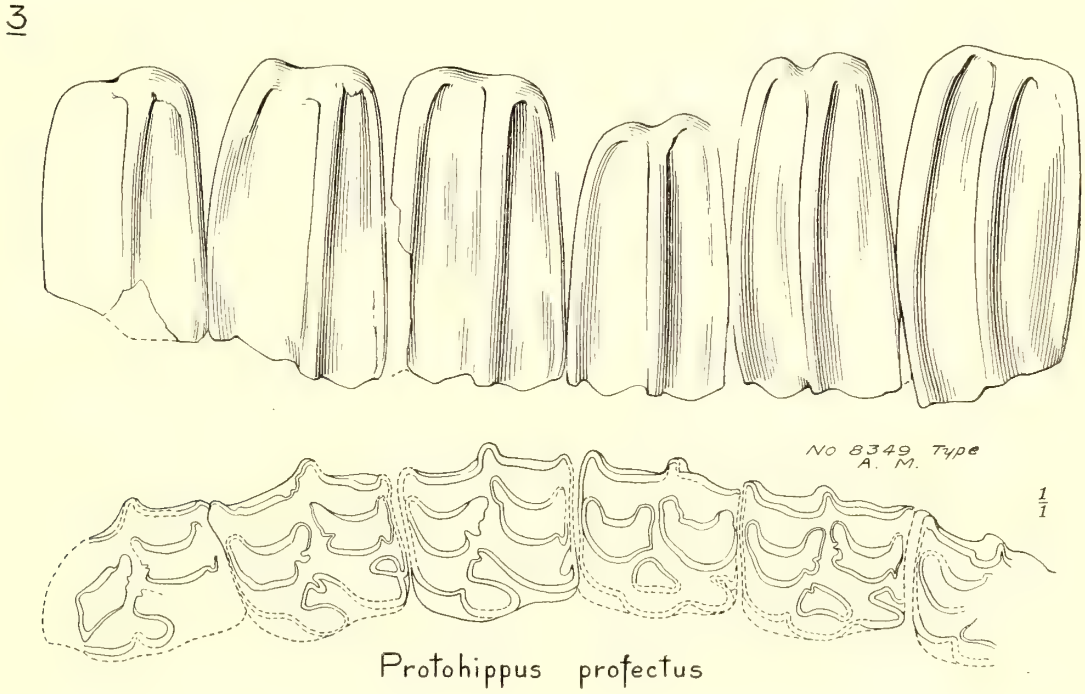

Fig. 115. Type of *Protohippus profectus* Cope, Amer. Mus. 8349, p^2–m^3 of the left side, as reassembled and partly restored. External and crown views. Natural size.

Horizon and locality.— (Cope) "From Phillips county, Kansas, from the Loup Fork bed." Type collected by Frank Hazard. Probably from the Republican River formation, Driftwood Creek, Nebraska, Peraceras zone, early Pliocene.

Type.— Amer. Mus. Cope Coll. 8349. Six superior molars from one individual found in the same locality as the type molars of *Protohippus retrusus*. Five of them are from one side and one (more worn) from the other side. Measurements: (Cope, 1889) p^2 a.p. .045, tr. .023, height of crown .019; m^3 a.p. .024, tr. .020, height of crown .036.

Type figure.— Plate 22.3, text Fig. 115 of this Memoir.

Characters.— (Cope, 1889, Osborn, 1918) (1) In dimensions the type of this species is about equal to "*Hippotherium*" *speciosum* [a referred specimen]; (2) "The other six (with one exception) are less worn, and present a less complex folding of the enamel plates [than in *Protohippus retrusus*]"; (3) protocone of the same flattened form as in *P. retrusus* but connected with protoconule by a narrow isthmus; (4) separated in two of the teeth from the metaconule; (5) p^2 presenting a complete fusion; (6) approaching nearer to *Equus* than any known species of *Equus* or *Hippidium*.

Gidley (1907, p. 908) observes that this species, like *P. retrusus*, is of doubtful reference and was not well characterized by Cope. Its greater size separates it from *P. retrusus*, although its characters, so far as they can be made out, seem to class it in the same group. Matthew (1913) observes that the imperfect teeth which form the type are closely allied to *P. perditus* but are somewhat shorter-crowned, with larger enamel lakes, and perfectly simple enamel borders. The referred hind limb and foot bones are exceptionally long and slender.

Protohippus perditus secundus mut. nov.

Plate 22.1. Text Fig. 116, 116a.

Horizon and locality.— Republican River beds, Driftwood Creek, western Nebraska, Peraceras zone, Upper Miocene or Lower Pliocene. Type collected by R. S. Hill.

Type.— Amer. Mus. Cope Coll. 8340, a series of upper grinding teeth of the right side, p^2–m^3, associated with pelvis, hind limb, and foot bones.

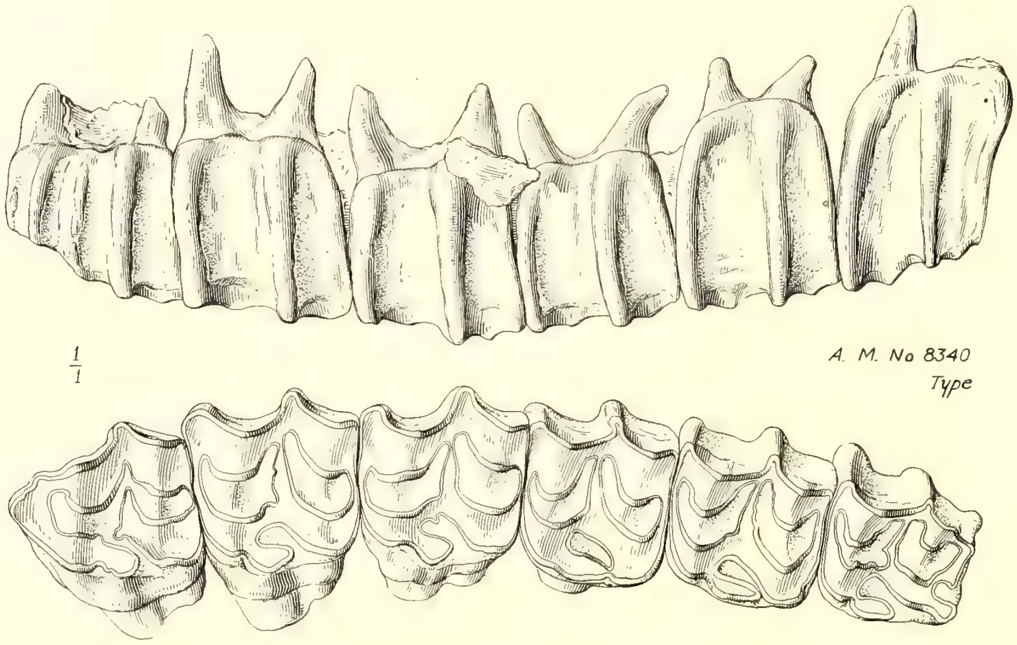

Fig. 116. *Protohippus perditus secundus* Osborn, Amer. Mus. Cope Coll. 8340. Crown and side views of the superior grinding teeth of the type, p^2–m^3 of the right side. Reversed in drawing. Natural size.

Type figure.— Plate 22.1, text Fig. 116, 116a.

Characters.— (1) Molar-premolar series (text Fig. 116a) somewhat exceeding in length that of the type of *P. perditus*. (2) Hind limb elongate; (3) metatarsal III slender, elongate, laterally compressed.

This animal is apparently a mutation beyond the typical *P. perditus*. The discovery of the foot bones of this form and of a referred *P. placidus* reveals the very important feature of the slender, elongate, laterally compressed central metapodials and the abbreviated lateral digits; anisotridactyly in contrast to the monodactyly of the contemporary *Pliohippus*.

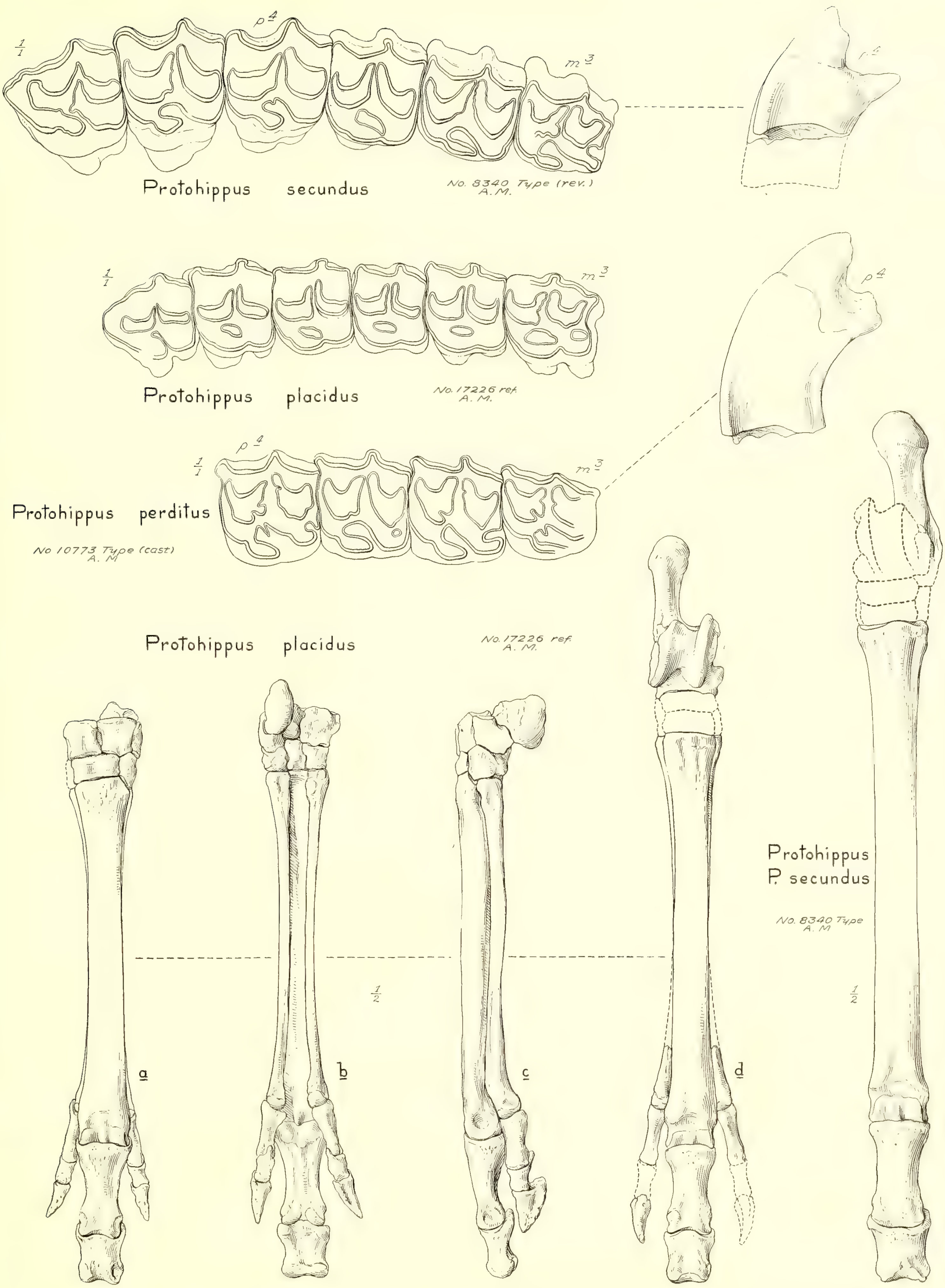

Fig. 116a. Type and Referred specimens of *Protohippus perditus* (cast Amer. Mus. 10773); *Protohippus placidus*, referred specimen, Amer. Mus. 17226; *Protohippus secundus*, type, American Museum 8340 (reversed in drawing).

(Three upper figures) Superior molar series showing the relative size of the grinding teeth of the three species in different degrees of size and evolution.

(Four lower left-hand figures) Fore and hind feet of *Protohippus placidus* (Amer. Mus. 17226), referred specimen, associated with the superior molar teeth discovered by Troxell.

(Lower right-hand figure) Hind foot of *Protohippus secundus*, type, Amer. Mus. 8340 (partly restored), associated with the type superior molars.

GENUS **PLIOHIPPUS** MARSH 1874.

Amer. Jour. Sci. and Arts, (3) Vol. VII, Mar. 1874, pp. 252–253.

Genotype.—Pliohippus pernix Marsh, from the Niobrara River, Nebraska, "Nebraska" formation, Procamelus-Hipparion zone.

The seventeen species now referred to the *Pliohippus* stage of evolution, include the *Pliohippus* (*Merychippus*) *mirabilis* Leidy 1858 from the Upper Miocene of the Niobrara River, also *P. supremus, P. pernix, P. robustus* from the same life zone, namely, the Procamelus-Hipparion zone. To this life zone belong also the *P. fossulatus* and *P. interpolatus* Cope from the Clarendon formation of Texas. Of slightly more recent age is the *P. nobilis* Osborn from the Republican River, Peraceras zone. There follow geologically the specimens referred to *P. interpolatus* and *P. supremus* from Snake Creek, western Nebraska, and the slightly more recent *P. tantalus* and *P. fairbanksi* from the Upper Ricardo bordering the Mohave Desert of Southern California. *P. coalingensis* of the Lower Etchegoin is evidently older than *P. simplicidens* (J. C. M.). The Middle Pliocene yields the *P. spectans* of the Rattlesnake formation of Oregon, and in full Middle Pliocene time there occur the *P. simplicidens, P. cumminsii,* and *P. minutus* of the Blanco formation, Glyptotherium zone of Texas. Of the same or slightly more recent age is the *P. proversus* of the Upper Etchegoin of San Joaquin Valley, Southern California. The latter species is extremely close to *Equus* in the crown pattern of its grinding teeth, in fact, the progressive evolution into the *Equus* molar crown pattern is a most distinctive character of *Pliohippus.* No less important is the monodactylism observed by Marsh in *P. pernix* and confirmed by Troxell. Thus the *Pliohippus* stages range gradually into the *Equus* stage.

The characters which prevail in these sixteen species and which exhibit marked evolution between Upper Miocene and Middle or Upper Pliocene times are chiefly the following:

1. Grinding teeth long, hypsodont, fully cemented.
2. Deciduous premolars short, hypsodont, fully cemented, inner basal cusp rudimentary or absent.
3. Protocone invariably united with protoloph, progressively larger than hypocone, of primitive round-oval, or progressive elongate anteroposterior oval form, as in *Equus.*
4. Characters of proto- and metaconules, of crochet, and of hypostyle derived from the *Merychippus-Protohippus* pattern.
5. Pre- and postfossettes typically broad, with relatively few plications of the enamel borders (unlike progressive *Merychippus* and *Hipparion*), *i. e.* single pli caballin, pli crochet, pli metaloph, pli hypostyle.
6. Superior grinders incurved (*P. supremus*).
7. Like *Merychippus campestris* and unlike known species of *Protohippus* a large malar fossa as well as a more or less distinct lachrymal fossa (*P. mirabilis, P. supremus, P. nobilis*).
8. In the lower grinders metaconid-metastylid column widely separate, fusing only at base.
9. Anteroexternal fold of lower teeth vestigial or absent.
10. Feet comparatively massive and heavy, ungual phalanges broad and flat.
11. A horizontal facet for cuboid on Mts. III, also a facet for mesocuneiform.
12. Fore and hind feet monodactyl or solipedal.

(W. D. M.) The species of *Pliohippus* in which the skull is known appear to be derived rather from a *Merychippus calamarius* stage than from any known species of *Protohippus*, according to Matthew's observation of 1913 on generic stages of *Protohippus, Pliohippus,* and *Hipparion.* They appear to represent three more or less parallel groups or phyla. They are distinct in the following features:

CHARACTERS	*Protohippus*	*Pliohippus*	*Hipparion*
Upper grinders	Straight or curved	Curved	Straight
Protocone	Small	Progressively enlarging	Progressively enlarging
Protocone	United to protoloph	United to protoloph	Separated from protoloph
Protocone	Typically round-oval	Expanding oval	Round or expanding flattened oval
Enamel fossette borders	Rather simple	Rather simple, fossettes large	Very complex, fossettes reduced
Metaconid-metastylid column	Partly separated	Partly separated	Widely separated
Preorbital fossæ	Lachrymal fossa only	Lachrymal and malar fossæ	Lachrymal, or lachrymo-malar fossæ
Foot structure	Tridactyl	Monodactyl or tridactyl	Persistently tridactyl

I. TYPE DESCRIPTIONS OF THE SPECIES OF PLIOHIPPUS IN CHRONOLOGIC ORDER.

Date	Original name and author	Present reference	Locality	Life zone
1858	*Merychippus mirabilis* Leidy	*Pliohippus mirabilis*	Niobrara River, Nebr.	Procamelus-Hipparion zone
1869	*Protohippus supremus* Leidy	" *supremus*	Little White River, Nebr.	" " "
1874.1	*Pliohippus pernix* Marsh	" *pernix*	Niobrara River, Nebr.	" " "
1874.2	" *robustus* Marsh	" *robustus*	" " "	" " "
1880	*H.* [*Hippidium*] *spectans* Cope	" *spectans*	Cottonwood Creek, Ore.	Pliohippus zone
1892	*Equus simplicidens* Cope	" *simplicidens*	Crosby County, Tex.	Glyptotherium-Pliohippus simplicidens zone
1893.1	*Protohippus fossulatus* Cope	" *fossulatus*	Mulberry Cañon, Good Night, Tex.	Procamelus-Hipparion zone
1893.2	*Hippidium interpolatum* Cope	" *interpolatus*	" " " " "	" " "
1893.3	*Equus cuminsii* Cope	" *cumminsii*	" " " " "	Glyptotherium-Pliohippus simplicidens zone
1893.4	" *minutus* Cope	" *minutus*	Mt. Blanco, Crosby Co., Tex.	" " " "
1913	*Pliohippus ?tantalus* Merriam	" *tantalus*	El Paso Range, So. Cal.	Pliauchenia-Peraceras zone
1914	*Protohippus coalingensis* Merriam	" *coalingensis*	North Coalinga, San Joaquin Co., Cal.	Glyptotherium-Pliohippus simplicidens zone
1915	*Pliohippus fairbanksi* Merriam	" *fairbanksi*	Near Ricardo Post-Office, Mohave Desert, Cal.	Pliohippus-Pliauchenia zone
1916.1	" *proversus* Merriam	" *proversus*	North Coalinga, San Joaquin Co., Cal.	" -proversus "
1916.2	" *lullianus* Troxell	" *lullianus*	Mission, So. Dak.	?Pliauchenia-Peraceras zone
1918.1	" *nobilis* Osborn	" *nobilis*	Long Island, Phillips Co., Kas.	Pliauchenia- " "
1918.2	" *leidyanus* Osborn	" *leidyanus*	Sioux Co., Nebr.	Peraceras-Pliohippus "

II. TYPES AS RECORDED OR INFERRED IN 1917 IN GEOLOGIC SUCCESSION.

Date	Species, Present reference	Life zone	Formation, Beds	Locality	Age
1916	*Pliohippus proversus* Merriam	Pliohippus proversus zone	Upper Etchegoin formation	North Coalinga, San Joaquin Co., Cal.	Middle Pliocene (upper levels)
1893.4	" *minutus* Cope	Glyptotherium-Pliohippus simplicidens zone	Blanco Formation (middle levels)	Mt. Blanco, Crosby Co., Tex.	" "
1893.3	" *cumminsii* Cope	" " "	" "	" " " " "	" "
1892	" *simplicidens* Cope	" " "	" "	Crosby Co., Tex.	" "
1914	" *coalingensis* Merriam	" " "	Lower Etchegoin formation	North Coalinga, San Joaquin Co., Cal.	" "
1880	" *spectans* Cope	Pliohippus zone	?Rattlesnake "	Cottonwood Creek, Ore.	Lower " (upper levels)
1915	" *fairbanksi* Merriam	Pliohippus-Pliauchenia zone	Ricardo (upper) "	Near Ricardo Postoffice, Mohave Desert, Cal.	" "
1913	" *tantalus* Merriam	Pliauchenia-Peraceras "	" (lower) "	El Paso Range, Southern California	" "
1918.2	" *leidyanus* Osborn	? " " "	Snake Creek, Neb.	Sioux Co., Neb.	" "
1918 1	" *nobilis* Osborn	" " "	Republican River formation	Long Island, Phillips Co., Kas.	" "
1916.2	" *lullianus* Troxell	? " " "	Oak Creek formation	Mission, So. Dak.	" "
1893.2	" *interpolatus* Cope	Procamelus-Hipparion "	Clarendon formation	Mulberry Cañon, Good Night, Tex.	Upper Miocene or Lower Pliocene
1893.1	" *fossulatus* Cope	" " "	" "	" " " " "	" " " " "
1874.2	" *robustus* Marsh	" " "	Niobrara River formation	Niobrara River, Nebr.	" " " " "
1874.1	" *pernix* Marsh	" " "	" " "	" " "	" " " " "
1869	" *supremus* Leidy	" " "	Little White River "	Little White River, Nebr.	" " " " "
1858	" *mirabilis* Leidy	" " "	Niobrara River "	Fort Niobrara, Nebr.	" " " " "

Matthew observes that certain species of *Pliohippus* approach the South American Pampean genera *Hippidium* and *Onohippidium*. Osborn considers that they are excluded from direct ancestry by certain characters, such as the deep malar fossæ. The known species of North American *Pliohippus* fall into the following partly progressive and partly phyletic stages and groups:

Group I, Upper Miocene.

Species with short-crowned teeth, approximating *Merychippus*.

Pliohippus mirabilis,

Group II, Upper Miocene and Lower Pliocene.

Long-crowned molars, heavy cement on both deciduous and permanent grinders.

Pliohippus pernix
" *supremus*
" *robustus*

Group III, Lower and Middle Pliocene.

Larger, long-crowned teeth, with broad fossettes, simple borders.

Pliohippus spectans
" *interpolatus*
" *nobilis*

Group IV, Middle Pliocene.

Crowns approaching *Equus* pattern.

Pliohippus simplicidens
" *cumminsii*
" *proversus*

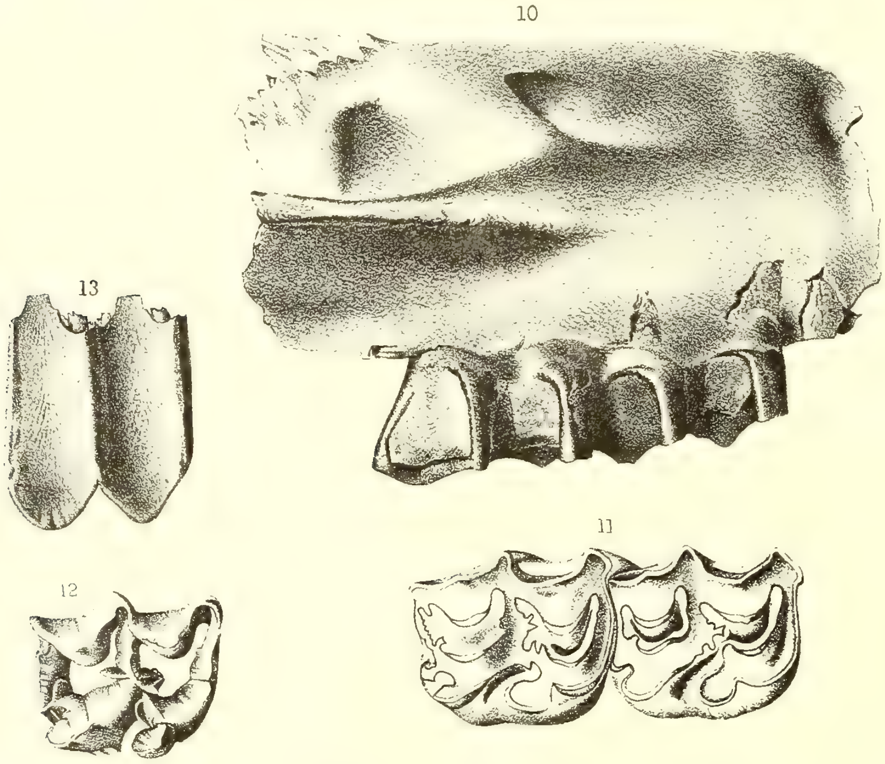

Fig. 117. Original figures of the type of *Pliohippus mirabilis* Leidy, U. S. Nat. Mus. 569. After Leidy 1869, pl. VII. (10) External view of fragment of type maxilla showing dp^3, ^{4}; (11) crown view of dp^3, ^{4}; (12) crown view of m^1 removed from the matrix; (13) side view of m^1. Natural size.

PROCAMELUS–HIPPARION–PLIOHIPPUS SUPREMUS ZONE. 13. LOWER PLIOCENE G. 32.

THE TYPICAL EXPOSURES OF THIS ZONE ARE ON THE NIOBRARA RIVER, BUT IT IS ALSO WIDELY DISTRIBUTED IN OTHER PARTS OF THE WESTERN UNITED STATES.

Pliohippus mirabilis Leidy 1858.

Plates 25.10, 26.3. Text Fig. 117.

Merychippus mirabilis, Leidy, Joseph. "Notice of Remains of Extinct Vertebrata, from the Valley of the Niobrara River, collected during the Exploring Expedition of 1857, in Nebraska, under the command of Lieut. G. K. Warren, U. S. Top. Eng., by Dr.

F. V. Hayden, Geologist to the Expedition," *Proc. Acad. Nat. Sci. Phila.* Vol. X, 1858, p. 27, no figure. "The Extinct Mammalian Fauna of Dakota and Nebraska," *Jour. Acad. Nat. Sci. Phila.* (2) Vol. VII, 1869, pp. 299–302, Pl. xvii, type, figs. 10–13, paratype, figs. 8, 9.

Horizon and locality.— Niobrara River, near Fort Niobrara, Nebraska, Upper Miocene. Type collected by F. V. Hayden, 1857.

Type.— U. S. Nat. Mus. 569. (Leidy, 1858) "It is indicated in the Niobrara collection, by a specimen previously noticed, consisting of a fragment of the upper jaw, containing the second and third temporary molars and their permanent successors." (Gidley, 1907, p. 883) "A fragment of the right maxillary containing the posterior two milk molars, and the first true molar partially calcified." Measurements: (Gidley, 1907, p. 883) dp^3 a.p. .024 tr. .021; dp^4 a.p. .026, tr. .021; m^1 a.p. .025, tr. .022.

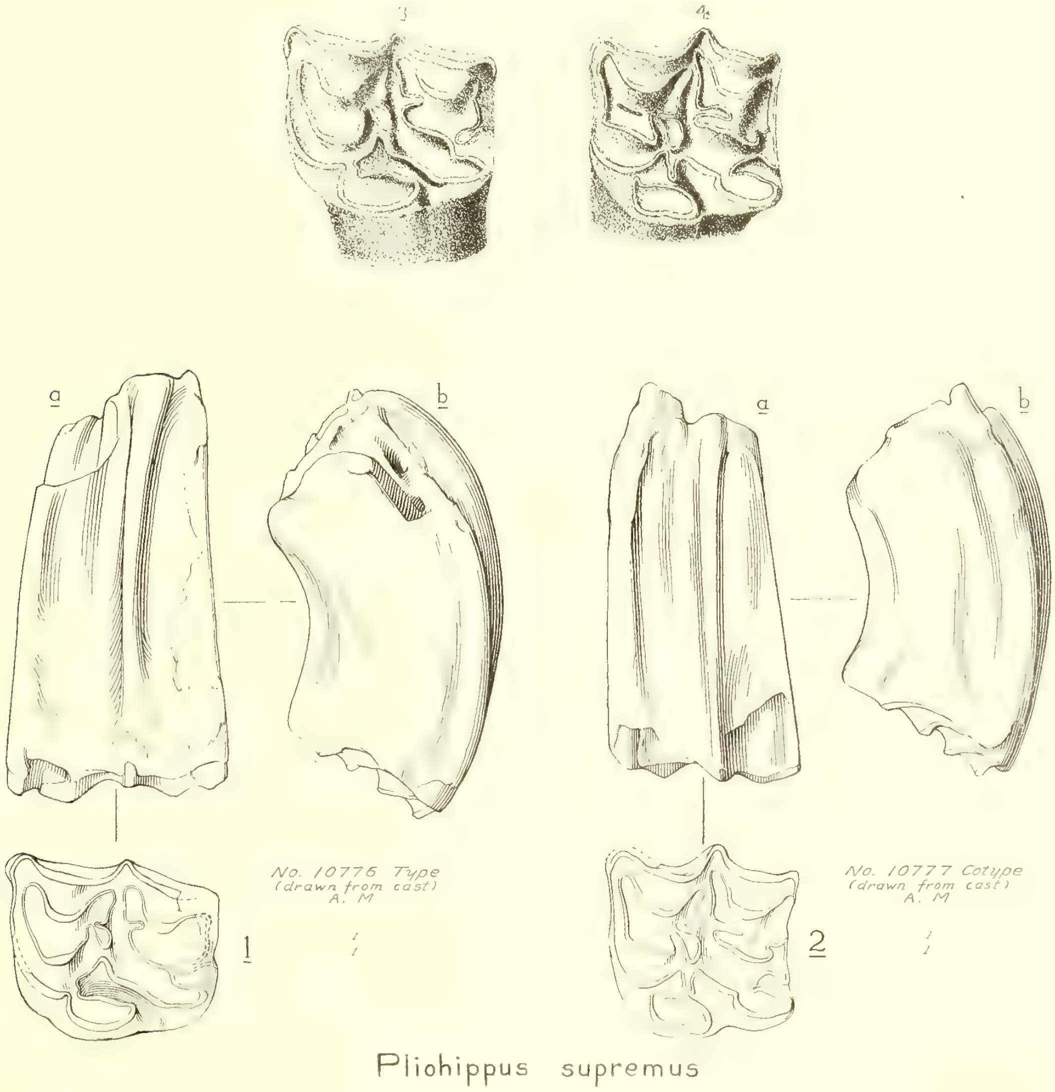

Fig. 118. Type and cotype of *Pliohippus supremus* Leidy, Acad. Nat. Sci. Phila. Coll., (Upper) Original figures after Leidy, 1869, Pl. xxvii, figs. 3, 4. Of these Leidy's description (p. 328) applies to fig. 4; hence Gidley selected this as the type. The cotype, fig. 3, belongs to another individual.

(Left lower) Drawings of the type from cast Amer. Mus. 10776, (1) crown, (a) external, and (b) anterior views. (Right lower) Drawings of cotype from cast Amer. Mus. 10777, (1) crown, (a) external, and (b) anterior views. All figures natural size.

Referred. U. S. Nat. Mus. 580 (Leidy, 1858) "Another specimen, in the same collection, belonging apparently to this species, consists of a fragment of the upper jaw of an adult individual, containing the back four molars, which are so far worn as to be inserted by fangs. (Measurements:) The four teeth occupy a space of three and one-third inches in length and an inch in breadth." Also Am. Mus. 10840.

Type figure.— Text Fig. 117 of this Memoir.

Characters.— (Leidy, 1858) (1) "...a deep depression or lachrymal fossa in advance of the orbit, as in the deer, Oreodon, etc." (Leidy, 1869, p. 294, Osborn, 1918) (2) Deciduous premolars provided with cement; (3) enamel foldings around the fossettes as simple as in the horse; (4) protocones conoid, continuous with protoconule; (5) protocone and hypocone on the same longitudinal plane and of equal size; (6) a pli caballin and single enamel fold entering the pre- and postfossettes from metaloph in m^1; (7) enamel of dp^{3-4} more ptychoid. Leidy's fuller description of his *Pliohippus* (*Merychippus*) *mirabilis* type is contained in his discussion of the genus *Merychippus* (1869, pp. 292–296).

Pliohippus supremus Leidy 1869.

Plates 25.11, 26.2, 31.3,4. Text Figs. 118, 119.

Protohippus supremus, Leidy, Joseph. "The Extinct Mammalian Fauna of Dakota and Nebraska," *Jour. Acad. Nat. Sci. Phila.* (2) Vol. VII, 1869, p. 328, type, Pl. xxvii, figs. 3, 4; neotype, Matthew, W. D., and Gidley, J. W. "New or Little Known Mammals from the Miocene of South Dakota," *Bull. Amer. Mus. Nat. Hist.* Vol. XXII, Art. VIII, May 26, 1906, p. 143, figs. 8, 9.

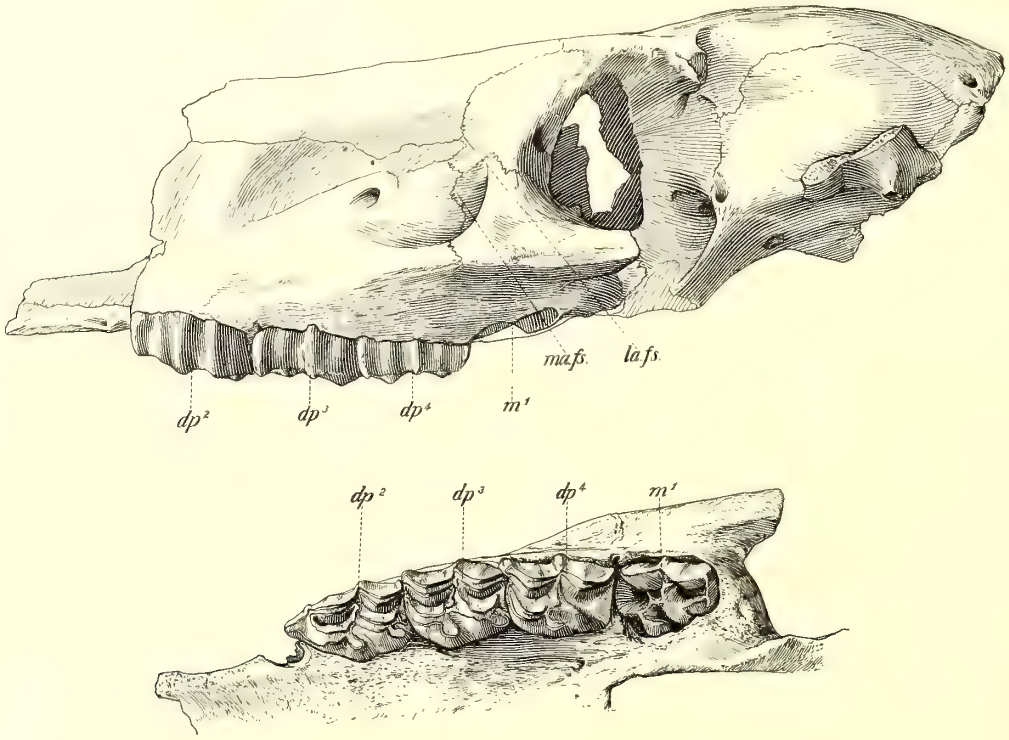

Fig. 119. Original figures of neotype (Gidley) of *Pliohippus supremus* Leidy, Amer. Mus. 10844, skull of young individual with milk premolars, dp^{2-4}. (Upper) Side view of skull, fig. 8, p. 143; (lower) neotype right maxillary with milk premolars, fig. 9, p. 144. *la. fs.*, lachrymal fossa, *ma. fs.*, malar fossa. Both figures one-half natural size. After Gidley, 1906.

Horizon and locality.— (Leidy, 1869, p. 326.) "...discovered on Little White River." Upper Miocene. Type collected by F. V. Hayden, 1866. Neotype from same locality.

Type and Cotype.— Acad. Nat. Sci. Phila. Coll. (casts Amer. Mus. 10776–7). (Leidy) Two superior molars of the left side, belonging to two different individuals in different stages of wear, of which Gidley selected that represented in Leidy's fig. 4 as the type. Measurements: (Leidy) external length of crown 22–26 lines. Gidley selected the molar represented in plate XXVII, Fig. 4, as the type (1907, p. 889), regarding it as m^1 or m^2, and recording the following measurements: m^1 a.p. .024 tr. .025, height of crown .048. He selected as a *neotype* (1907, pp. 889–890) Amer. Mus. 10844, a considerable portion of a juvenile skull and lower jaws containing the milk teeth dp^{2-4}, m^1.

Type figure.— Text Fig. 118 of this Memoir.

Characters.— (Leidy, 1869, p. 328, Osborn, 1918) (1) Superior molar teeth bear a resemblance to those of *Protohippus perditus;* (2) protocone isolated in the unworn crown (Fig. 4); (3) protocone early connected by wear with protoconule; (4) prominent, simple enamel folds entering pre- and postfossettes from median portion of metaloph; (5) a pli caballin and prominent enamel fold entering prefossette from crochet region; (6) protocone of elongate-oval section, projecting farther inward than hypocone. (Characters based on neotype, Gidley, 1907, p. 890) (7) Size considerably exceeding that of *Pliohippus mirabilis.* (8) Deciduous premolars of narrower proportions than in *P. mirabilis;* (9) greater complexity of the enamel foldings in both the milk and permanent series. (10) Malar fossa without dividing ridge, comparatively smaller and more shallow than in *P. mirabilis;* (11) basisphenoid proportionately longer than in *Protohippus perditus*, not overlapped by vomer. (Matthew, 1913, from type and neotype) (12) Deciduous premolars decidedly more hypsodont than in *Pliohippus mirabilis;* (13) permanent molars with long crowns; (14) protocone united with protoloph except near summit of crown; (15) protocone united with hypocone when teeth are well worn; (16) protocone oval, rather large, anterior in position on premolars; (17) fossette borders with a few enamel folds, disappearing when tooth is about half worn; (18) pli caballin well developed toward the summit of crown.

Referred specimens are Amer. Mus. 10844, 10848.

Pliohippus pernix Marsh 1874.

Plates 25.12, 28.1. Text Figs. 120, 121, 122.

Pliohippus pernix, gen. et sp. nov., Marsh, O. C. "Notice of New Equine Mammals from the Tertiary Formation," *Amer. Jour. Sci. and Arts*, (3) Vol. VII, No. 39, Mar. 1874, pp. 252–253, no figure.

Horizon and locality.— (Marsh, 1874, p. 253) "The specimen here described was exhumed by the writer, in June last, from the Pliocene sands of the Niobrara River, Nebraska." (Lull, letter Oct. 23, 1915) "It was collected by the expedition [Yale College] of 1873, somewhere along the Niobrara River, east of Antelope Creek, Nebraska, by H. Clifford and Professor Marsh." The exact locality has not been determined; it is somewhere within fifty miles of Antelope Creek. Nebraska formation, Upper Miocene.

Type.— Yale Mus. 13007. (Marsh, 1874, p. 252) "A new genus of solipeds, allied to *Equus*, is well represented in the Yale Museum by two partial skeletons, with the more important portions preserved, and by numerous fragmentary remains." The main type of *P. pernix*, Yale Mus. 13007, is of an old individual. (Lull, letter Oct. 23, 1915) "Catalogue number 13007 and 13007a, mainly one individual but evidently including part of another. The main individual [Yale Mus. 13007] consists of portions of a skull, jaws, the right pes, part of the left tibiæ, and so on. Also the left manus, radius, ulna and humerus, and several vertebræ. The left superior premolar series is complete." Measurements: (Marsh, 1874) extent of four upper premolars .088; three upper molars .068; of lower molar series, p_2–m_3, .146; length of radius .253; length of third metatarsal .208.

Type figure.— Plate 28.1, text Figs. 120, 121, 122 of this Memoir.

Characters.— (Marsh, 1874, p. 252) (1) Differs from *Protohippus* in the absence of lateral digits, which are only represented by slender splint bones; (2) presence of large antorbital [lachrymal] fossa; (3) presence of functional first upper premolar. (4) First lower premolar wanting; (5) molars with short crowns and distinct fangs; (6) enamel folds of the molar teeth very simple; (7) skull comparatively short; (8) ulna shaft incomplete at centre; (9) distal end of ulna and fibula coalesced with radius and tibia respectively; (10) small trapezium; (11) a rudiment of the fifth metacarpal attached to the unciform; (12) limbs more elongate than in *Equus asinus;* (13) size about that of *Equus asinus;* (14) ungual phalanges broader and slightly cleft at their extremities; (15) relatively large cubo-astragalar facet. (Gidley, 1907, p. 893)

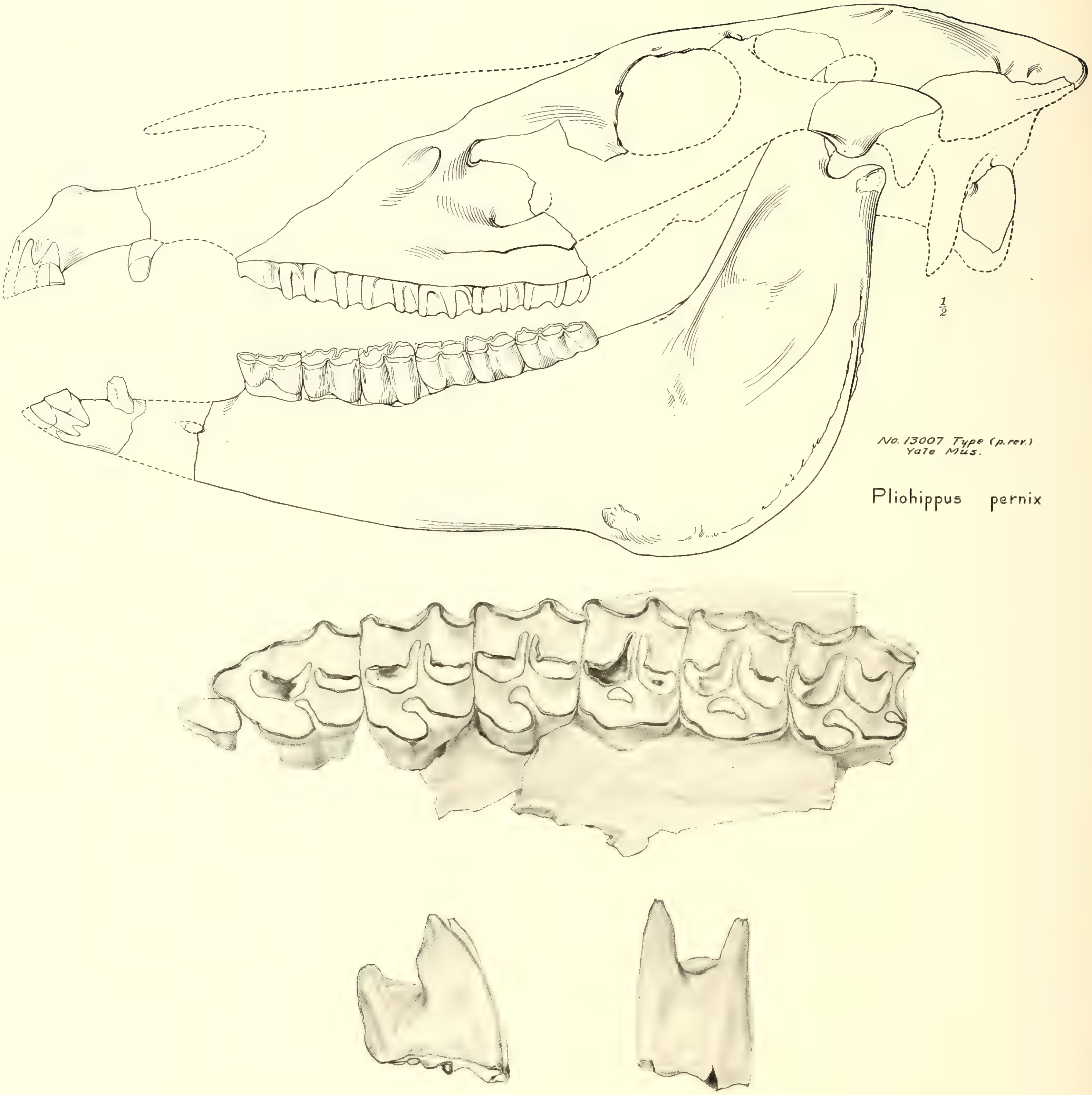

Fig. 120. (Upper) *Pliohippus pernix* Marsh, Yale Mus. 13007, skull of the type as reconstructed by R. S. Lull. Partly reversed in drawing. (Middle) Superior molar teeth of the type, p^2–m^3 of the left side. (Lower) Anterior and external view of an isolated molar tooth. Skull one-half natural size, teeth natural size. Middle and lower drawings by S. Oka.

(16) The type an old individual with teeth so much worn as to obliterate distinctive characters. (17) Lateral metapodials broken. (18) As compared with *Equus* the preorbital region is short; (19) angle of the jaw of great depth, and molars proportionately short-crowned and curved; (20) characteristic facial pits, or fossæ, including (?) a deep lachrymal pit.

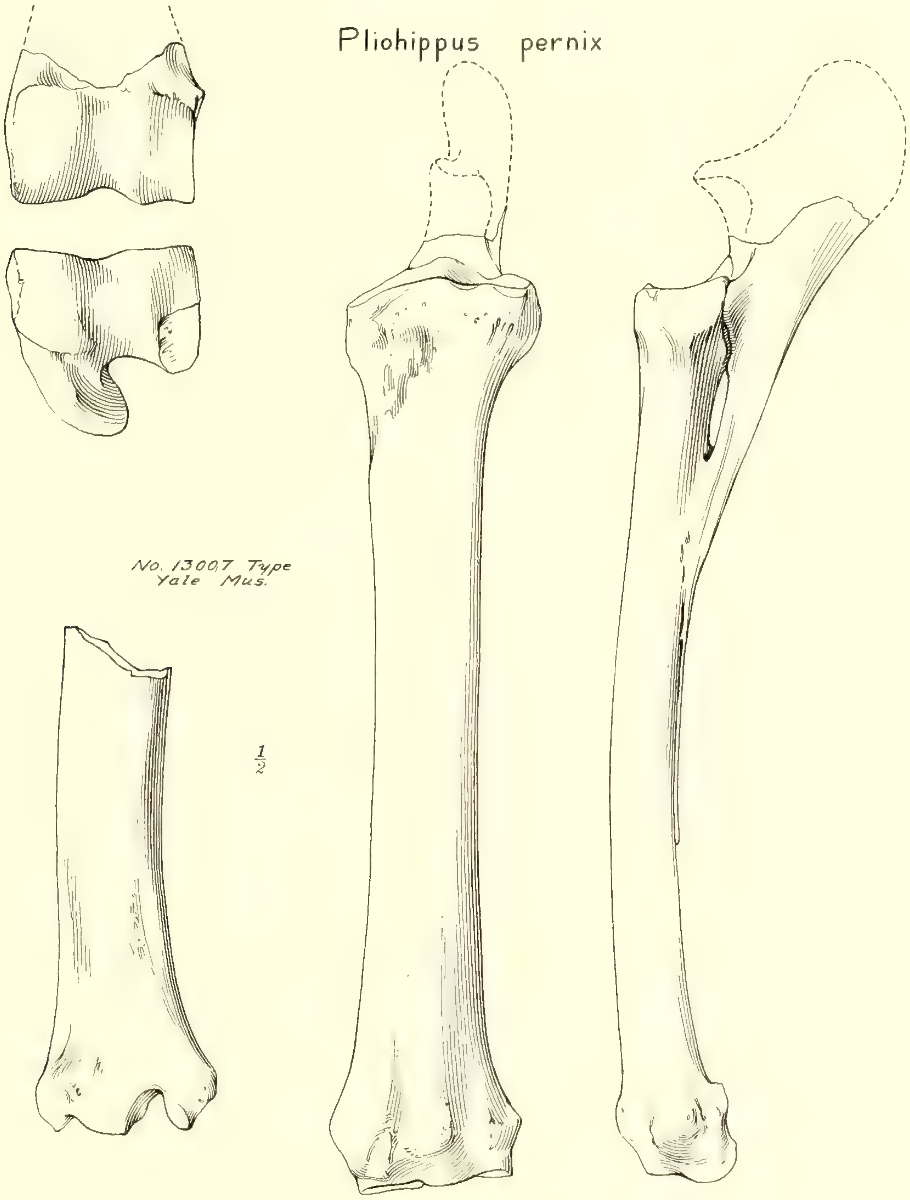

Fig. 121. *Pliohippus pernix* Marsh, Yale Mus. 13007. (Left upper) Left humerus of the type, anterior and inferior views; (middle and right) left ulna and radius of the type, anterior and external views; (left lower) distal view of tibia of the type. All figures one-half natural size.

(Matthew, 1913) The species *Pliohippus pernix* is doubtfully separable from the type of *Pliohippus supremus* Leidy.

Troxell[1] has recently (1916) discovered the skeleton of *Pliohippus lullianus*, not far removed from *P. pernix*, which verifies Marsh's definition that *Pliohippus* differs from other equine in the absence of lateral digits.

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[1] Troxell, Edward L. "An Early Pliocene One-Toed Horse, *Pliohippus lullianus, sp. nov.*" *The Am. Jour. of Science*, (4), Vol. XLII, No. 250, Oct. 1916, pp. 335–348, figs. 1–7.

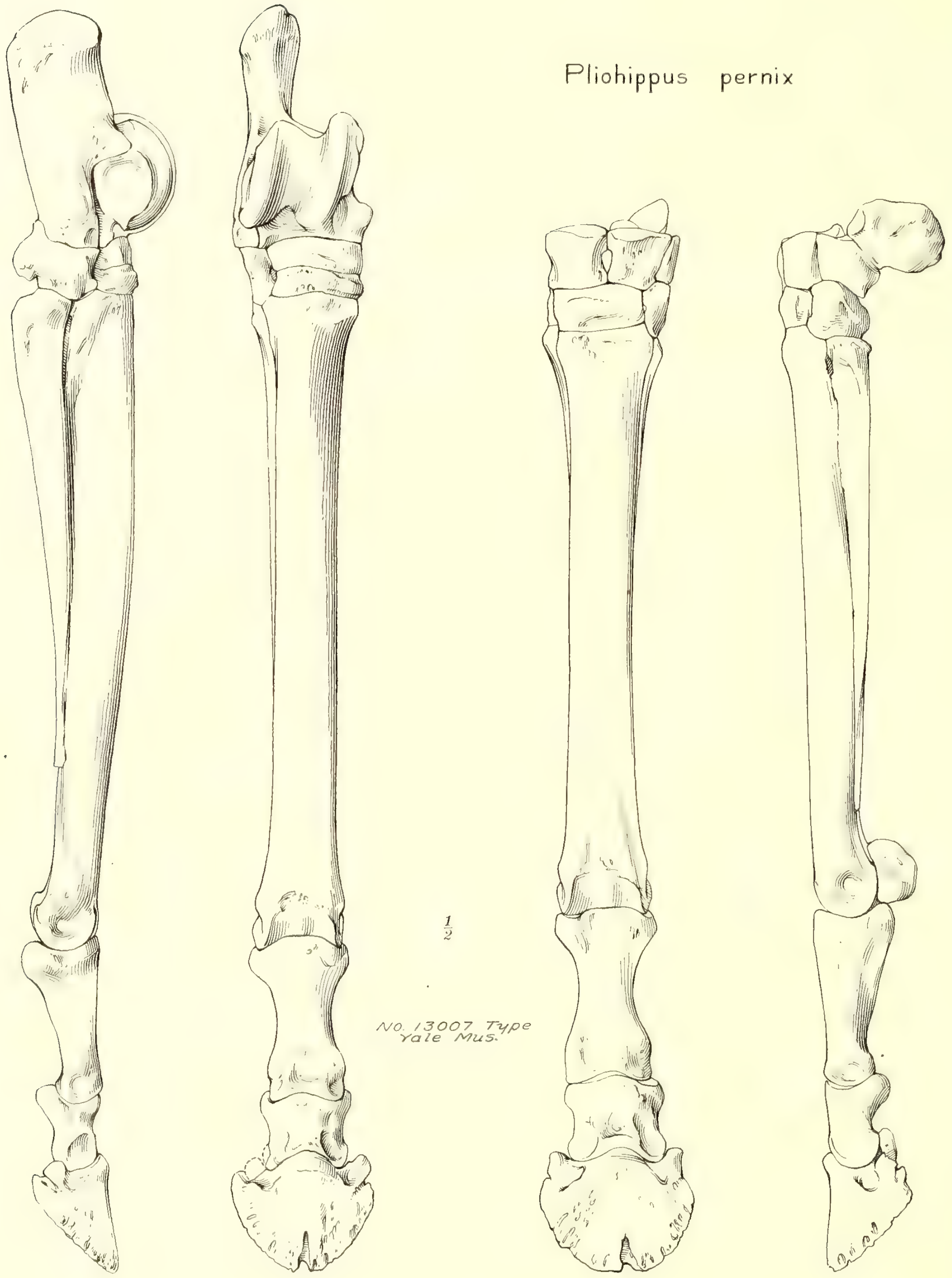


Fig. 122. *Pliohippus pernix* Marsh, Yale Mus. 13007. (Left) Right pes of the type, anterior and external views; (right) left manus of the type, anterior and external views. All figures one-half natural size.

(W. D. M., 1915) The fore limb of the type of *Pliohippus pernix* indicates that Mtc. III thickens slightly toward the distal end, not unlike Troxell's specimen of *Pliohippus*. The hoof is of a broad, flat type. Mtc. II carries a small facet for the trapezium.

A referred specimen is Amer. Mus. 10836.

Pliohippus robustus Marsh 1874.

Text Fig. 123.

Pliohippus robustus, sp. nov., Marsh, O. C. "Notice of New Equine Mammals from the Tertiary Formation," *Amer. Jour. Sci. and Arts*, (3) Vol. VII, No. 39, March, 1874, p. 253, no figure.

Horizon and locality.— (Marsh) "The known remains of this species were found by the writer, last summer [*i. e.* 1873], in the Pliocene strata of the Niobrara River." (Lull, letter of Oct. 23, 1915) "Collected by the expedition of 1873 from the Niobrara River; collector O. C. Marsh. Type locality probably not far from that of *P. pernix*." Nebraska, Upper Miocene.

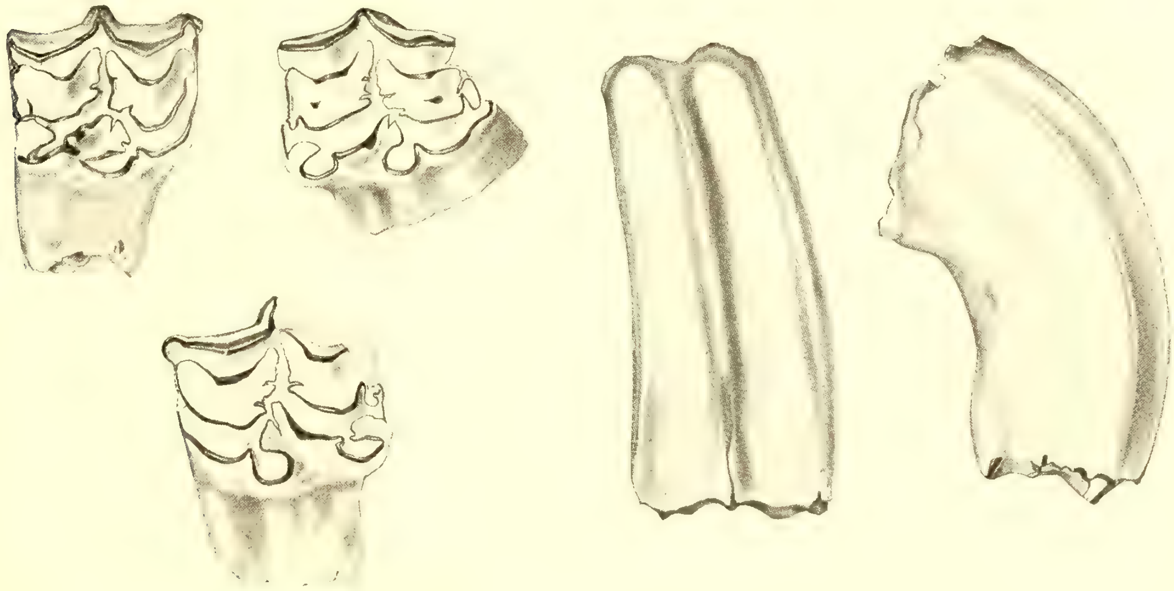


Fig. 123. *Pliohippus robustus* Marsh, Yale Mus. 13008, superior molars of type. (Left upper centre) Crown view of right p^2; (left lower) crown view of left p^3; (left upper) crown view of right m^2. (Two right-hand figures) Outside and anterior views of right m^2. All figures natural size. Drawings by S. Oka.

Type.— Yale Mus. 13008 (Lull, letter Oct. 23, 1915) [A young adult individual] consisting of upper teeth, fragments of the skull, fore and hind feet, radius, humerus, etc. Measurements: (Gidley, 1907) p^2 a.p. .029, tr. .0225; p^3 a.p. .026, tr. .024; m^2 a.p. .025, tr. .022, height of crown, outside, .062.

Type figure.— Text Fig. 123 of this Memoir.

Characters.— (Marsh, 1874, p. 253) (1) Of nearly the same size as the type of *Pliohippus pernix*, but limbs shorter and stouter; (2) the first upper premolar much larger, the upper molars longer and much curved; (3) enamel foldings more complex than in *P. pernix*. (Gidley, 1907, p. 894) (4) Aside from the difference in the proportions of the bones, the characters assigned by Marsh are indicative of age differences only, the type of *P. robustus* being a young adult, that of *P. pernix* an aged individual; (5) the comparative measurements of limb and foot bones indicate that *P. robustus* is a shorter animal and of more robust proportions; (6) terminal phalanx well rounded, with the posteroexternal processes much reduced as in the modern horse, but the plane of the proximal articular facet directed more backward as in the other species of Miocene horses. (7) This species is not clearly distinguished from *P. supremus* Leidy, with which it agrees in size and general characters so far as they are known.

(Matthew, 1913) *P. robustus* Marsh agrees with *P. supremus* Leidy.

Pliohippus fossulatus Cope 1893.

Plate 23.1,1a, 24.1. Text Figs. 124, 125.

Protohippus fossulatus Cope, Cope, E. D. "A Preliminary Report on the Vertebrate Paleontology of the Llano Estacado," *Fourth Ann. Rept. Geol. Surv. Texas* (1892) 1893, pp. 30–32, Pls. v, vi, vii.

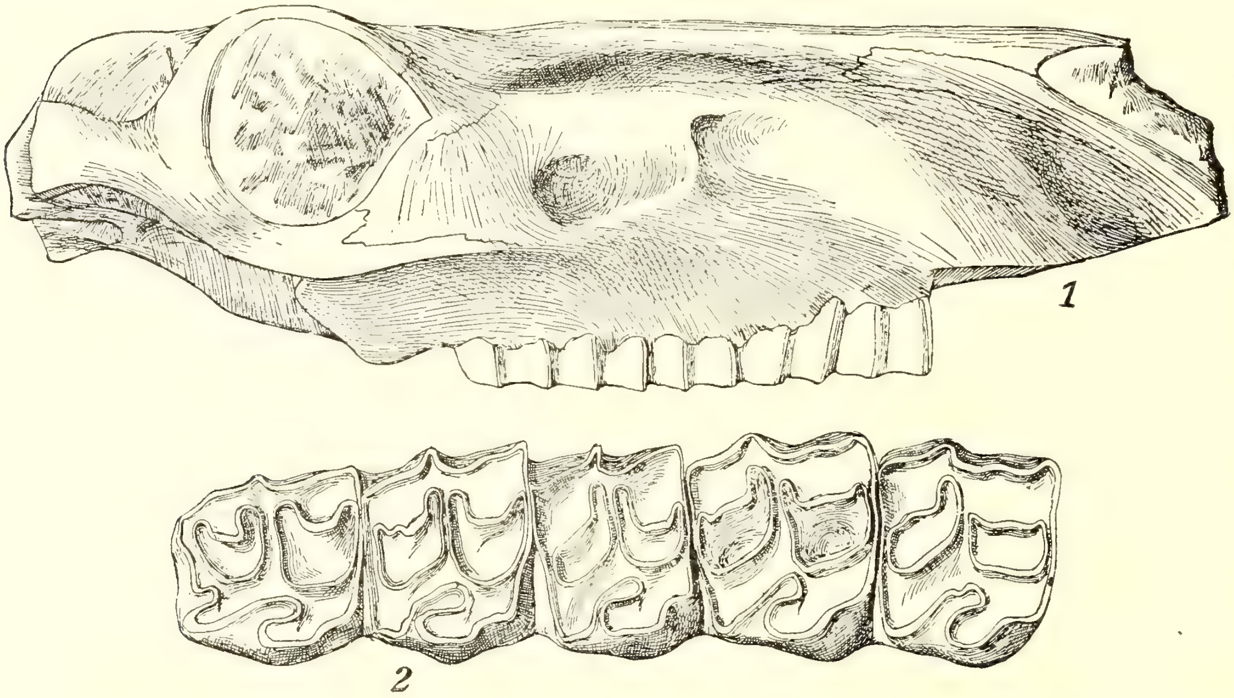


Fig. 124. Original figures of (1) side view of the skull and (2) crown view of the right premolar-molar series (p^3–m^3) of the type of *Pliohippus fossulatus* Cope, Univ. Texas Coll. (cast Amer. Mus. 14395). After Cope (1892) 1893, Pl. v. Skull one-half natural size, teeth natural size.

Horizon and locality.— (Cope) "...found by Mr. W. F. Cummins in the Loup Fork formation of Donley county, Texas." Clarendon formation, Upper Miocene.

Type.— Univ. Texas Coll. (cast Am. Mus. 14395). (Cope) "Represented by a cranium, which has lost all, posterior to the posterior frontal region and anterior to the premaxillary border." Measurements: (Cope) length from posterior border of orbit to extremity of nasal bones .235; m^1 a.p. .020, tr. .025; total length of molar series .145; length of true molar series .069.

Type figure.— Text Figs. 124, 125 of this Memoir.

Characters.— (Cope) (1) Size between that of *Pliohippus pachyops* and *P. mirabilis.* (2) No fossa immediately in front of the orbit, but there is a narrow and deep maxillo-nasal fossa [lachrymal], the posterior extremity of which approaches nearer to the superior part of the orbit than any other; (3) beneath it and immediately above the penultimate molar tooth (m^2) a small but well pronounced fossa [malar]; (4) immediately anterior to the infraorbital foramen is a wider and shal-

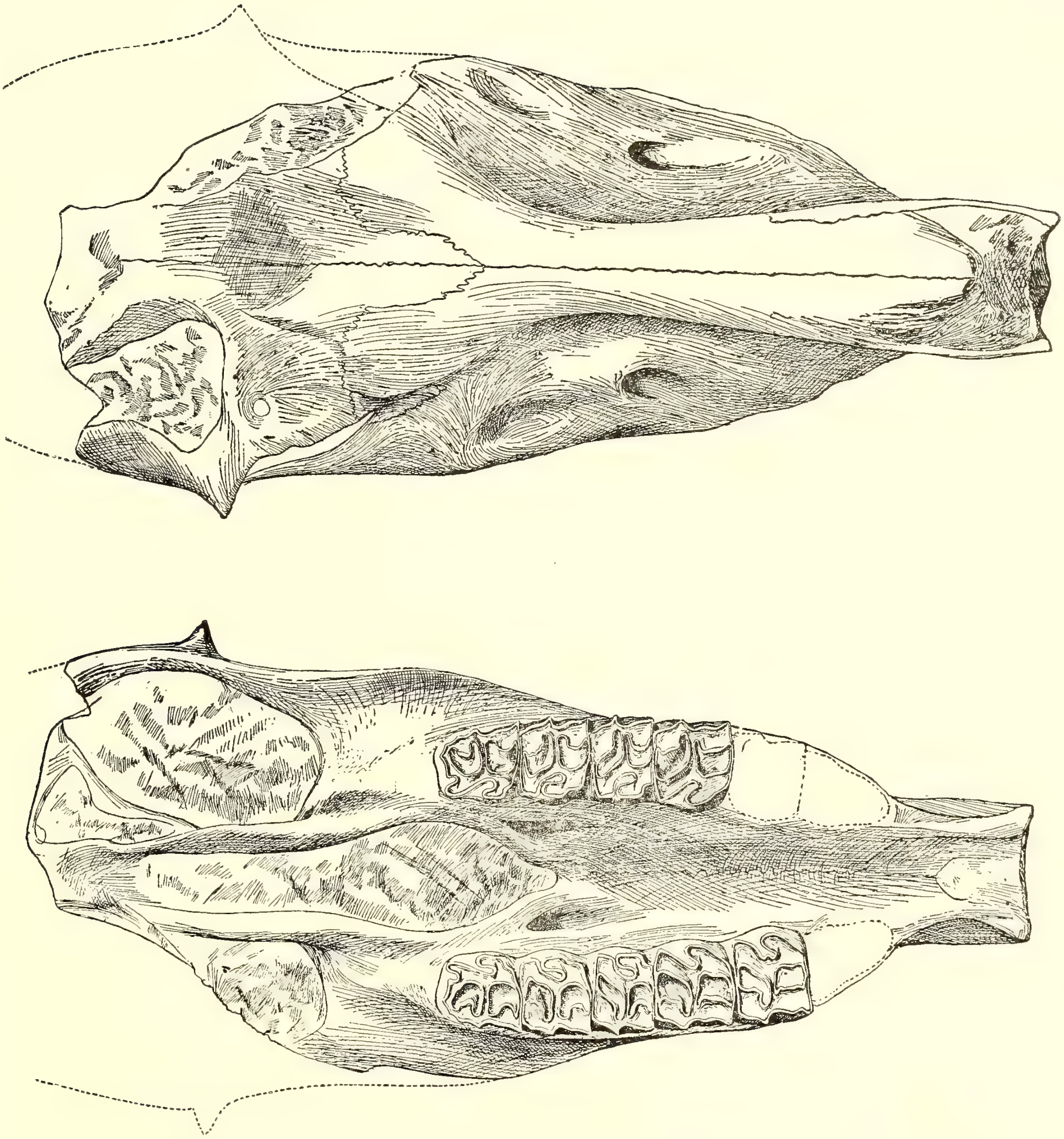


Fig. 125. Original figures of the type of *Pliohippus fossulatus* Cope, Geol. Surv. Tex. Coll. (cast Amer. Mus. 14395). Top and palatal views of the skull. After Cope (1892) 1893, (upper) Pl. vi, (lower) Pl. vii. Both figures one-half natural size.

lower fossa [maxillary]; (5) infraorbital foramen above anterior border of m^1; (6) anterior border of orbit above posterior border of m^3. (7) Grinding faces of the molar crowns wider than long; (8) protocone large and well fused, projecting more prominently inward than the hypocone, which is not distinct in any of the teeth; (9) enamel borders perfectly simple, with no loop between the protocone and hypocone. (Gidley, 1907, p. 915) (10) Its general skull characters more nearly approach those of *Protohippus perditus* as that species is now understood, especially in the form and position of the lachrymal fossa, also in the presence of a deep depression on the upper surface of the skull in the median line directly between the orbits, as in *P. perditus*; (11) it also agrees with *P. perditus* in the unusual broadening of the nasals anteriorly; (12) the comparative shortness of the preorbital region; (13) the deep constriction of the preorbital region immediately in front of the premolars. A distinction is (14) the presence of an incipient malar fossa, and the greater depth of the lachrymal fossa. (Osborn, 1918) (15) Grinding teeth deeply worn, all enamel foldings obliterated; (16) extreme transverse diameter due to the basal section of the crown; (17) protocone prominent, constricted; (18) hypocone region somewhat less prominent, unconstricted.

Pliohippus interpolatus Cope 1893.

Plates 24.6, 25.13. Text Fig. 126.

Hippidium interpolatum, Cope, Cope, E. D. "A Preliminary Report on the Vertebrate Paleontology of the Llano Estacado," *Fourth Ann. Rept. Geol. Surv. Texas* (1892) 1893, pp. 42–43, Pl. xii, figs. 3, 3a, 4.

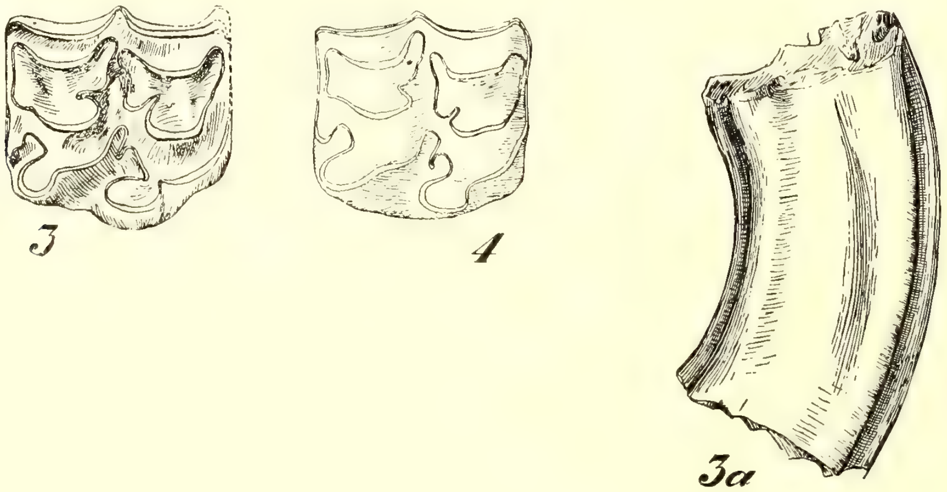


Fig. 126. Original figures of the type of *Pliohippus interpolatus* Cope, Univ. Texas Coll. (cast Am. Mus. 14387). (*3*) Grinding face of m^2; (*3a*) posterior view of crown of m^2; (*4*) grinding face of supposed m^1. Natural size. After Cope, 1893, Pl. xii, figs. 3–4.

Horizon and locality.— Mulberry Cañon, near Goodnight, Texas, "Goodnight beds," Clarendon formation, Upper Miocene. Type collected by Mr. W. F. Cummins, (p. 40) "near Goodnight's on the Staked plain."

Type.— Univ. Texas Coll. (cast Am. Mus. 14387). (Cope) "Established on two right superior molars, probably derived from the same animal. They are apparently the first and second true molars." Measurements: (Cope, p. 42) m^1 a.p. .028, tr. .027; m^2 a.p. .029, tr. .0295, height of crown .065.

Type figure.— Text Fig. 126 of this Memoir.

Characters.— (Cope, 1893, Osborn, 1918) (1) Distinguished from corresponding teeth of *Protohippus* by the small size of protocone and hypocone; (2) protocone uniting with protoconule; (3) a pli caballin and crochet fold in prefossette, (4) single enamel fold in postfossette; (5) hypostyle region simple, fossettes relatively large, borders relatively simple; (6) crowns curved transversely but not anteroposteriorly; (7) cement abundant.

Gidley observes (1907, p. 917) (1) that the type molars are of a young adult individual, hence the fossettes are

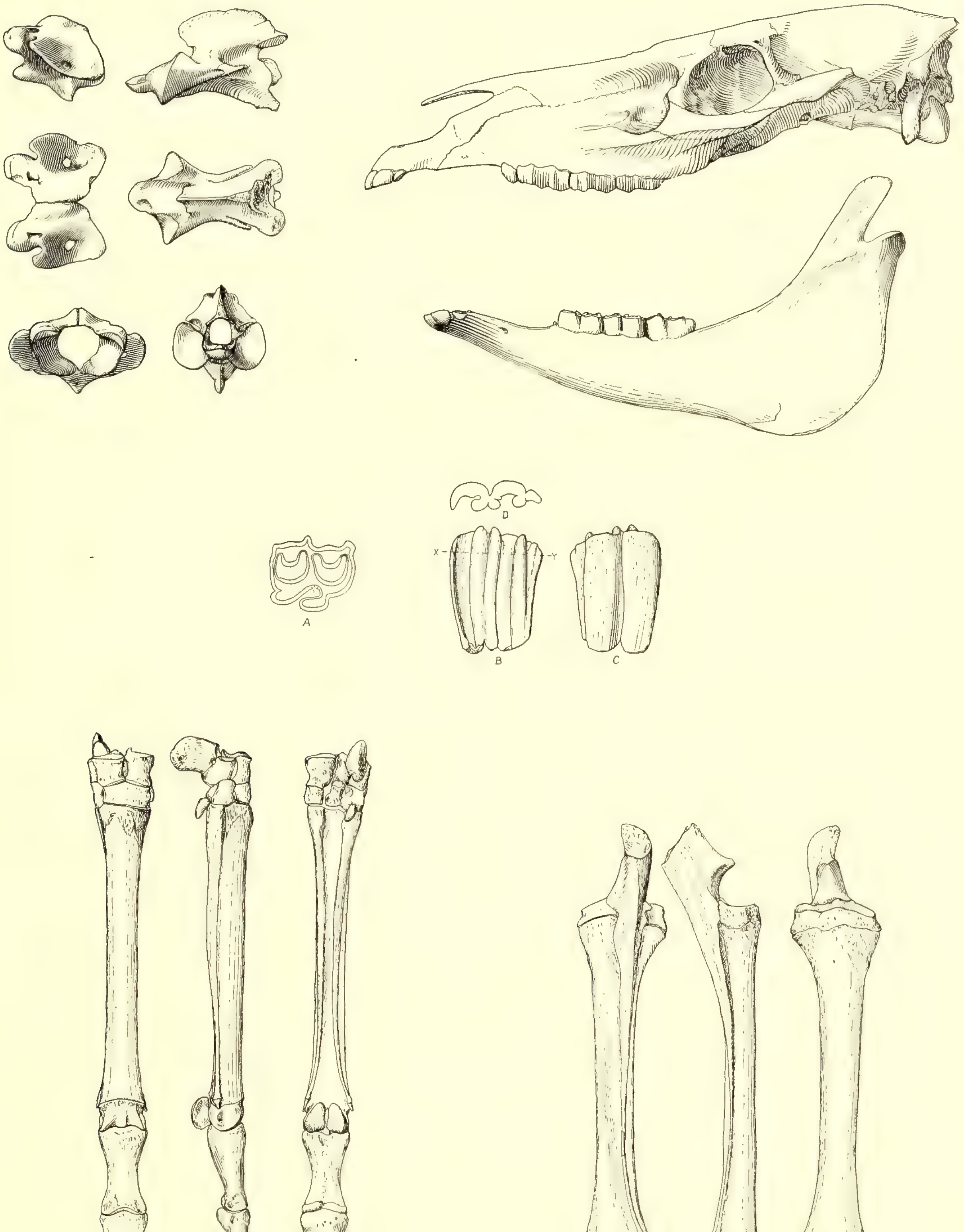


Fig. 127. Original figures of the type of *Pliohippus lullianus* Troxell, Am. Mus. 17225. (Left upper) Atlas and axis, dorsal and anterior views; (right upper) side view of skull and ramus; (centre) A, section 1 cm. from the crown of first true upper molar, B and C, inner and outer views of first true lower molar, D, section of B on line X–Y; (left lower) right manus, front, side, and back views; (right lower) radius and ulna, rear, side, and front views. All except centre figure one-fourth natural size; centre figure one-half natural size. After Troxell, 1916, figs. 1–5, pp. 338–340.

narrower than they would be in a greater degree of wear; (2) the simplicity of the enamel foldings, the small rounded protocone, the degree of curvature of the tooth crown, resembling the northern species of *Pliohippus;* (3) the animal agrees in size with *P. spectans* Cope.

(Matthew, 1913) (1) Size large, about equalling *P. spectans;* (2) protocone larger than in *P. spectans,* of flattened oval shape; (3) fossettes not as wide as in *P. spectans;* (4) distinguished from *P. pernix* by larger size and more hypsodont molars; (5) from *P. spectans* by less reduction of protocone.

A referred specimen is Amer. Mus. 13900a.

Pliohippus lullianus Troxell, 1916.

Plate 27. Text Fig. 127.

Pliohippus lullianus sp. nov. "An Early Pliocene One-Toed Horse, *Pliohippus lullianus* sp. nov." *The Amer. Jour. of Sci.* (4), Vol. XLII, No. 250, Oct., 1916, pp. 335–348, figs. 1–7.

Horizon and locality.— (Troxell, pp. 345, 346) "The skeleton of the new type was found in the eastern part of the Rosebud Indian Reservation, near the town of Mission, South Dakota. This Reservation, at least the western part in the Miocene formation of the valley of the Little White River, has long been a favorite hunting ground for specimens of extinct animals. . . . The fauna of this Oak Creek formation corresponds closely with that of the Snake Creek Beds of Western Nebraska; the latter, though resembling the Republican River Beds of Western Kansas, show a more modernized type of animal life and are considered by Matthew and Cook to be intermediate between the Blanco of Texas and the Upper Miocene. The Oak Creek formation, while in some respects like the Etchegoin of California, Middle Pliocene, is not so far advanced and in all probability belongs to the Early Pliocene." Type collected by E. L. Troxell.

Type.— Amer. Mus. 17225. (Troxell, p. 336.) " . . . . the skeleton of a young colt about ten months old. The milk teeth are all visible and some are slightly worn; the first permanent true molar is well formed and about ready to be cut — it has, however, no apparent cement. The loose epiphyses and the incompletely ossified bones also attest the immaturity of the individual."

Type figure.— Text Fig. 127 of this Memoir.

Characters.— (Troxell, pp. 341–343) "*Metacarpals.*— The especial character which distinguishes this specimen is its monodactyly. It has commonly been predicted that one-toed specimens of the Protohippinæ would be found, but no positive evidence of this feature has, heretofore, been presented. The splints, Metacarpals II and IV, unlike those of *Equus,* extend the lengths of the cannon bone, but like those of the modern horse they bear no digits on the ends. These slender bones are large proximally, but at once decreasing in size they run at a uniform diameter to the middle; in the next fourth of the distance they decrease to a width of about 3 mm. and a thickness of less than 1.5 mm. The distal ends are enlarged to receive the pointed epiphyses, the larger one of which measures 6 mm. in length. They show no evidence of articular facets; in fact their very sharp ends eliminate the possibility of their ever having borne phalanges."

PLIAUCHENIA-PERACERAS-PLIOHIPPUS NOBILIS ZONE. 14. LOWER PLIOCENE.

The typical exposures of this zone are on the Republican River, western Kansas.

Pliohippus nobilis sp. nov.

Plates 26.4, 28.4. Text Fig. 128.

Horizon and locality.— From the Republican River formation, Long Island, Phillips County, Kansas. Type collected by American Museum Expedition of 1894.

Type.— Amer. Mus. 2668. An upper jaw containing p^3–m^3 of the left side, also p^2 and m^{2-3} of the right side. Teeth about three-fifths worn.

Type figure. Plates 26.4, 28.4, text Fig. 128 of this Memoir.

Characters.— (Matthew, 1913, Osborn, 1918) (1) Size very large, p^2–m^3 .180, p^1–m^3 .190e; (2) protocone prominent, exceeding hypocone in size, united to protoloph by a narrow isthmus, united to hypocone when molars are over half worn; (3) protocone obliquely oval on premolars, flattened oval and relatively large on molars; (4) lingual side convex, buccal side flat (m^3); (5) fossettes expanded; (6) indication in worn crowns of pli caballin and crochet fold in prefossette, two or more enamel plications from metaloph into pre- and postfossettes (m^3); (6) malar fossa very deep; (7) lachrymal fossa extensive, its upper border unknown.

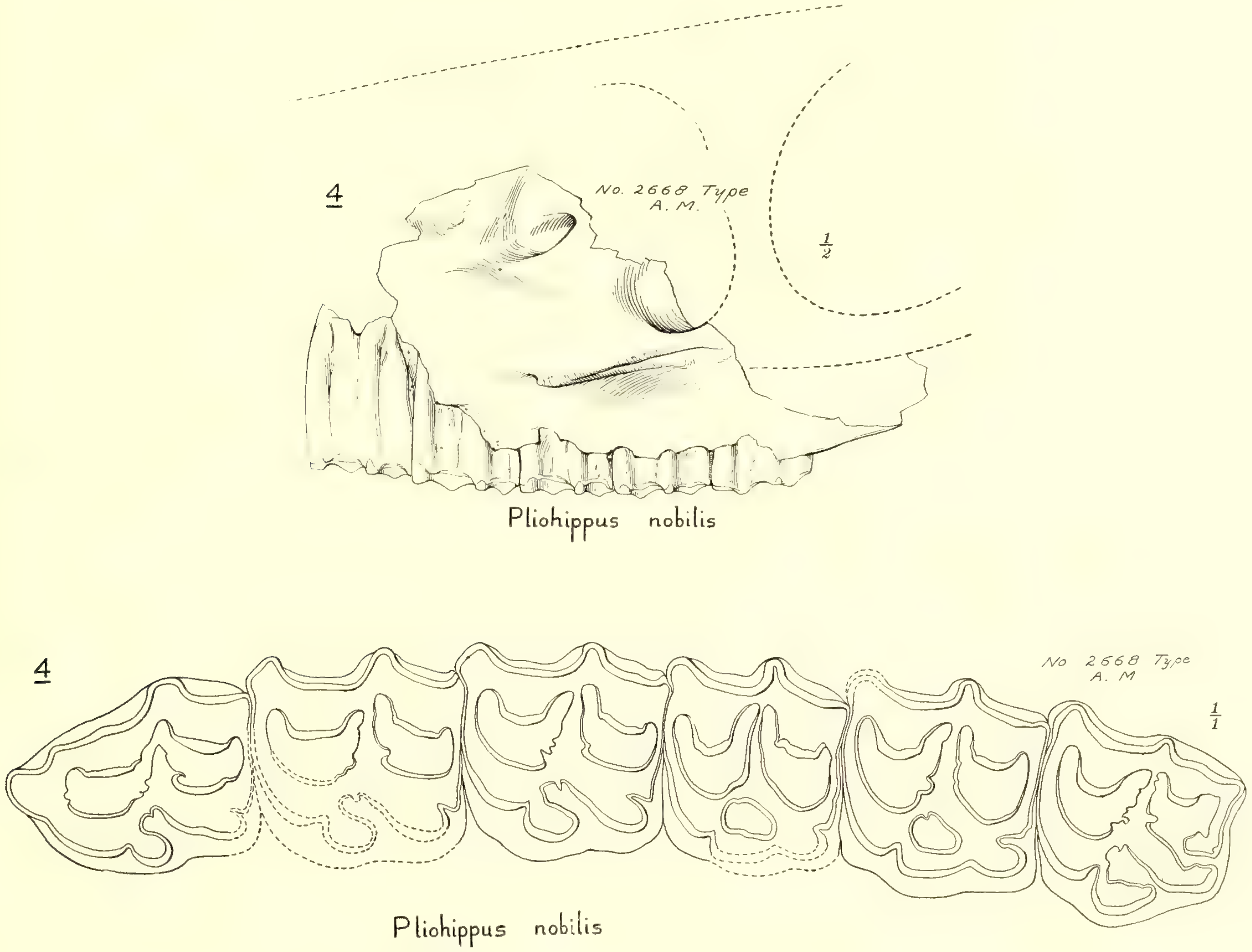


Fig. 128. Type of *Pliohippus nobilis* Osborn, Amer. Mus. 2668. (Upper) Lateral view of maxillary, one-half natural size; (lower) crown view of cheek teeth, p^2–m^3, of the left side, natural size.

Matthew observes (1913) that this animal equals in dental size the Pampean *Hippidium.* The deeper malar fossa especially distinguishes the skull. The characters of the feet are unknown. Other evidence of the presence of a very large horse in the Republican River Upper Miocene is afforded by the splints of a Mts. IV which may or may not have been connected with the terminal phalanges.

Pliohippus leidyanus sp. nov.

Plates 28.3, 29, 30.1,2. Text Fig. 129.

Horizon and locality.— From the Snake Creek formation, Sioux County, western Nebraska. Type collected by Harold J. Cook for the American Museum of Natural History in 1915–1916.

Type.— Amer. Mus. 17724. Skull, jaws, vertebræ, fore and hind limbs, considerable portions of the ribs and other parts of the skeleton, all of one individual. The dentition indicates that the type is a nearly adult female, about six years of age, the last grinding tooth, m^3, just coming into use.

Type figure.— Plates 29, 30, text Fig. 129 of this Memoir.

Characters.— (1) Intermediate in size between the Niobrara species *Pliohippus supremus, P. robustus, P. pernix* and the Republican river species *P. nobilis.* (2) Orbits small; (3) malar and lachrymal fossæ absent; (4) shallow maxillary fossæ just anterior to the junction of the maxillaries with the lachrymals (Plate 30.1). (5) Grinding teeth similar in enamel pattern to other species of *Pliohippus* in similar stages of wear, *i. e.* plications relatively simple; (6) grinding teeth (Plate 30.2) more elongate than in *P. supremus* (Fig. 118) and *P. robustus* (Fig. 123).

The type skull and dentition appear to be specifically distinct from previously described forms in the exceptional position of the preorbital fossæ on the sides of the maxillaries, as contrasted with the very distinct double, or lachrymo-malar fossæ in the types of *P. mirabilis, P. supremus, P. pernix, P. lullianus,* and *P. nobilis.*

Facial pits.— Comparison of these fossæ in male and female skulls of *Merychippus, Protohippus,* and *Pliohippus,* as represented in Plates 20–30 of this Memoir, indicates that they are secondary sexual characters, strong and double in males, single and feebly developed in females. The closest analogy to the maxillary fossæ of the *P. leidyanus* female type is another female type, namely, *Protohippus niobrarensis* Gidley (Plate 21.2), also the female neotype of *Protohippus perditus* (Plate 21.3).

The finely preserved fore and hind feet confirm the evidence afforded in the type of *P. lullianus* that these animals are absolutely monodactyl, or solipedal.

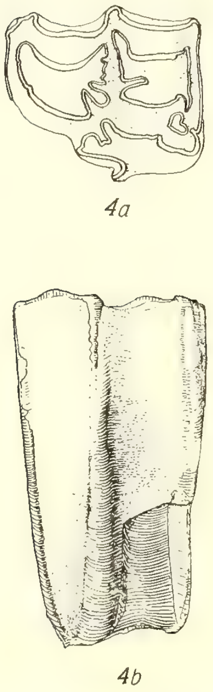


Fig. 130. Original figures of the type of *Pliohippus tantalus* Merriam, Univ. Cal. Pal. Coll. 19434, p^4 (?). Natural size. After Merriam, 1913, figs. *4a, 4b*, p. 441.

Pliohippus tantalus Merriam 1913.

Text Fig. 130.

Pliohippus (?) *tantalus,* n. sp., Merriam, John C. "New Protohippine Horses from Tertiary Beds on the Western Border of the Mohave Desert," *Univ. Cal. Publ. Bull. Dept. Geol.* Vol. 7, No. 23, Dec. 22, 1913, pp. 440–441, figs. 4a, 4b.

Horizon and locality.— From the Ricardo formation, Lower Pliocene, El Paso range, Southern California. Type collected by expedition of the University of California.

Type.— (Type) Univ. Cal. Pal. Coll. 19434 (cotype) 21221. Two large upper cheek teeth. Measurements: (type, 19434), p^4, a.p. .0248, tr. .024, height of crown .048.

Type figure.— Text Fig. 130 of this Memoir.

Characters.— (Merriam, 1913, p. 440) (1) Protocone and protoconule united; (2) crown curved; (3) fossettes large, wide, with complicated enamel on both borders of the metaloph, and with single projections into pre- and post-fossettes; (4) a single crochet fold in the prefossette; (5) a pli caballin; (6) outer styles heavy and narrow, noticeably above the base.

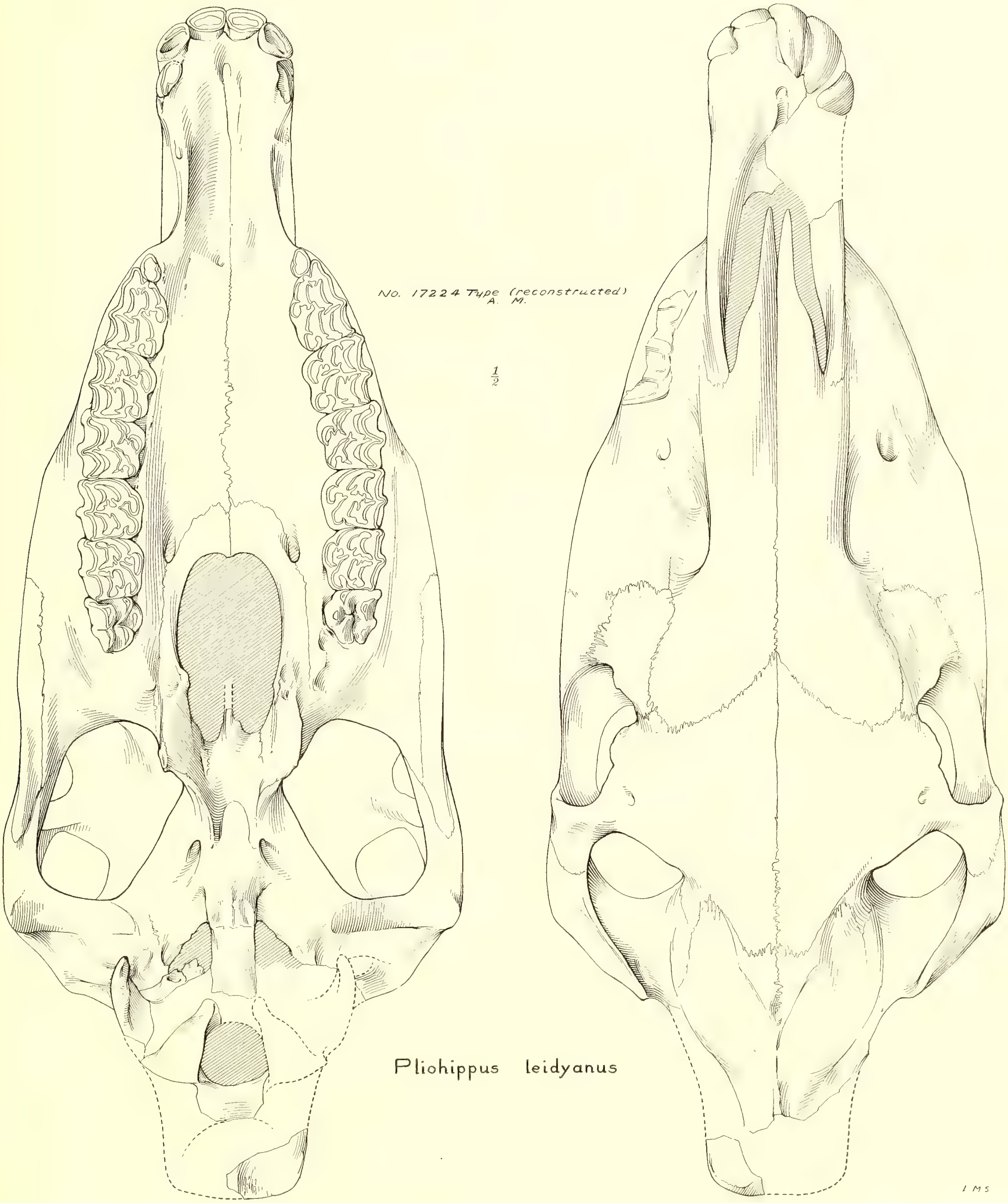


Fig. 130. Skull of the type of *Pliohippus leidyanus* Osborn, Amer. Mus. 17724. One-half natural size.

Pliohippus fairbanksi Merriam 1915.

Text Fig. 131.

Pliohippus fairbanksi, n. sp., Merriam, John C. "New Horses from the Miocene and Pliocene of California," *Univ. Cal. Publ. Bull. Dept. Geol.* Vol. 9, No. 4, Nov. 22, 1915, pp. 55–56, figs. 8a–8c.

Horizon and locality.— ". . . .from the Ricardo Pliocene, near Ricardo Postoffice, California." Mohave Desert. Type collected by the expedition of the University of California.

Type.— Univ. Cal. Pal. Coll. 19789. (Merriam) ". . . . a large unworn upper cheek-tooth p^4?." Measurements: p^4, height of crown on outer side .055, a. p. .025, tr. .0264.

Type figure.— Text Fig. 131 of this Memoir.

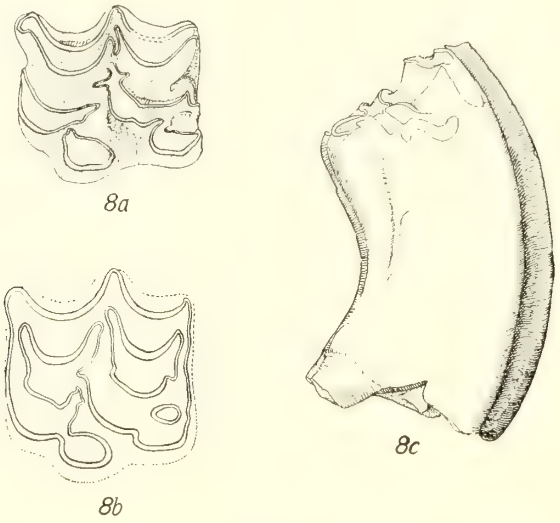


Fig. 131. Original figures of the type of *Pliohippus fairbanksi* Merriam, Univ. Cal. Pal. Coll. 19789, p^4 (?). (*8a*) Crown view, (*8b*) section taken across upper third of crown, (*8c*) posterior view. Natural size. After Merriam, 1915, p. 55.

Characters.— (Merriam, 1915, p. 55) (1) A protohippine form differing considerably from *Pliohippus tantalus* of the Ricardo Pliocene. (2) Crown a little more strongly curved; (3) para-, meso-, and metastyles heavier, fossettes narrower and of a different form; (4) protocones small, round, united with protoconule after wear; (5) protoconule remaining separate from metaconule almost to the base of the tooth; (6) no indication of pli caballin; (7) single fold projecting from metaloph into prefossette and postfossette.

PLIAUCHENIA–PLIOHIPPUS SPECTANS ZONE. 15. MIDDLE PLIOCENE.

The typical exposures are the Rattlesnake, Oregon, containing the typical type *Pliohippus spectans* Cope.

Pliohippus spectans Cope 1880.

Plate 28.2. Text Fig. 132.

H. spectans, Cope, E. D. "A New Hippidium," *Amer. Naturalist,* Vol. XIV, No. 3, Mar., 1880, p. 223, no figure. "The Perissodactyla," *Amer. Naturalist,* Vol. XXI, No. 12, Dec., 1887, p. 1072, fig. 41, *a, b.*

Horizon and locality.— "Loup Fork" beds, Cottonwood Creek, Oregon, "almost certainly Rattlesnake formation." (J. C. Merriam, Jan. 3, 1917) Middle Pliocene. Type collected by Professor Thomas Condon.

Type.— Amer. Mus. Cope Coll. 8183, a left superior molar, m^2, and an associated or referred upper premolar, p^2. (Cope, 1880, p. 223) "It is represented as yet by superior molar teeth only." Measurements: (Cope, 1880) second premolar a.p. .035, tr. .021, height of crown .035; m^2 a.p. .027, tr. .027, height of crown .045.

Type figure.— Text Fig. 132 of this Memoir.

Characters.— (Cope, 1880) (1) Molar teeth of larger size than those of any of the extinct American horses excepting *Equus excelsus*, about equalling those of *Hippidium neogœum* Lund; (2) crowns very long, slightly curved; (3) roots short; (4) internal columns [protocone, hypocone] relatively small, subequal in size, flattened in outline; (5) fossettes of great transverse width, equal to the anteroposterior diameters; (6) crescents [pa, me, pl, ml] correspondingly narrow; (7) enamel borders of fossettes simple, there being only a few notches on the adjacent faces; (8) one loop [pli caballin] projecting from inner enamel border almost reaching anterior inner column [protocone]; (9) cement abundant; (10) a crochet fold projecting into prefossette.

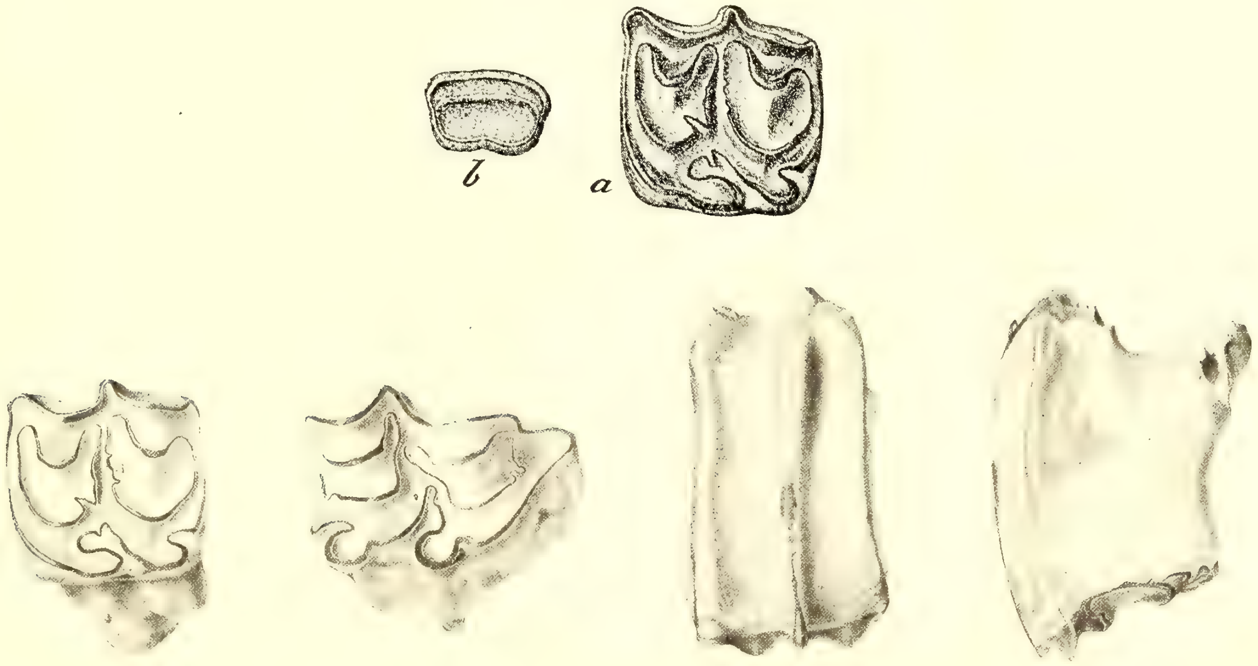


Fig. 132. (Upper) Original figure of the type of *Pliohippus* (*Hippidium*) *spectans* Cope, Amer. Mus. 8183. (*a*) Crown view of superior molar, (*b*) incisive surface of crown showing coating. Natural size. After Cope, 1887, fig. 41, p. 1972. (Lower) Type of *Pliohippus spectans* Cope, Amer. Mus. 8183, left superior molar, m^2, and associated or referred upper premolar, p^2 of the right side. External and interior views of m^2. Natural size. Drawings by S. Oka.

Matthew observes (1913): "This species belongs to the group characteristic of the Pliocene, larger animals with large fossettes, little complication of enamel, very heavy mesostyle and parastyle, and long-crowned teeth, strongly curved. Protocone strongly united to protoloph, small, oval, anterior in position. Fossettes broad with almost no plications."

Pliohippus coalingensis Merriam 1914.

Text Figs. 133.

Protohippus coalingensis, Merriam, John C. "Correlation between the Tertiary of the Great Basin and That of the Marginal, Marine Province in California," *Science*, N. S. Vol. XL, No. 1035, Oct. 30, 1914, p. 644, no figure. *Pliohippus coalingensis*, "Tertiary Vertebrate Faunas of the North Coalinga Region of California," *Trans. Amer. Philos. Soc.* N. S. Vol. XXII, Pt. III, Nov. 10, 1915, p. 230, figs. 29a, 29b.

Horizon and locality.— Lower Etchegoin, ten miles north of Coalinga, California. Type from locality 2073. The faunal zone near the base of Etchegoin in the North Coalinga region represents a distinctly more advanced stage than that of the Jacalitos. Name of collector not given.

Type.— Univ. Cal. Pal. Coll. 21341. A fourth superior premolar, p^4, of the right side. Measurements: (Merriam, 1915) p^4 a.p. .0272, tr. .0244, height of crown .053.

Type figure.— Text Fig. 133 of this Memoir.

Characters.— (Merriam, 1914, 1915) (1) Type belonging to an animal of medium size, approaching in dimensions *Pliohippus supremus.* (2) Differs from *P. supremus* in the heavier mesostyle, relative narrowness (in transverse diameter) of the crown even toward the base, narrower fossettes, much less plicated enamel walls of fossettes, much smaller, more nearly circular protocone. (3) Resembles *P. fairbanksi* of the Ricardo approximately in size, in simplicity of fossettes, in the very small, round protocone, and weak connection of the protoloph and metaloph; (4) differs from *P. fairbanksi* in the narrower and less curved crown of the molar teeth, the narrowness being apparently a normal character of worn teeth; (5) possibly separated only by subspecific characters from *P. fairbanksi.* (6) A larger and more progressive stage than the *Pliohippus* or *Protohippus* species of the Jacalitos.

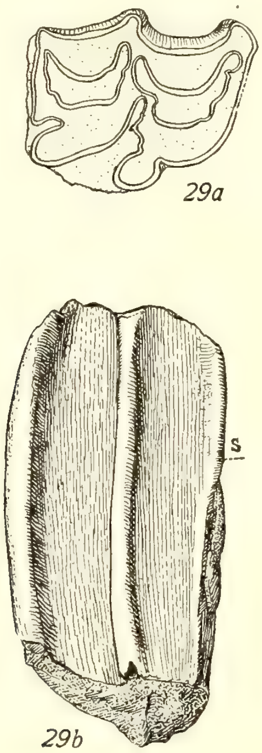


Fig. 133. Original figures of the type of *Pliohippus coalingensis* Merriam, Univ. Calif. Pal. Coll. 21341, p^4. Natural size. Fig. 29*a* Cross section of tooth at point indicated by *s* on fig. 29*b*; fig. 29*b* outer view. After Merriam, 1915, p. 230.

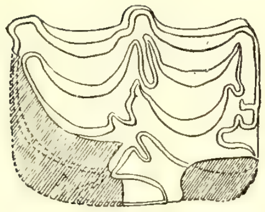
GLYPTOTHERIUM-PLIOHIPPUS SIMPLICIDENS ZONE. 17. FULL MIDDLE PLIOCENE.

THE TYPICAL EXPOSURES OF THIS ZONE ARE THE BLANCO, TEXAS. IT IS CHARACTERIZED BY THE PRESENCE OF SEVERAL SPECIES OF *PLIOHIPPUS* AND BY THE ABSENCE OF THE *PROTOHIPPUS* STAGE.

Pliohippus simplicidens Cope 1892.

Plates 24.5, 28.5. Text Fig. 134.

Equus simplicidens sp. nov. Cope, Edw. D. "A Contribution to the Vertebrate Paleontology of Texas," *Proc. Amer. Philos. Soc.* Vol. XXX, No. 137, Mar. 30, 1892, pp. 124–125, fig. 1.



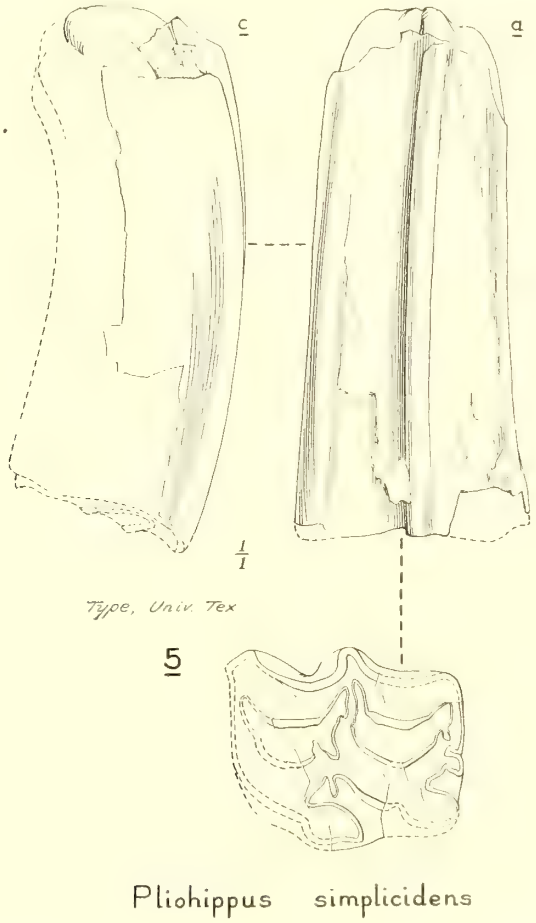


Fig. 134. *Pliohippus simplicidens* Cope, Univ. Texas Coll. (cast Am. Mus. 14388). (Left) Original figure of the type true molar, of the left side. After Cope, 1892, fig. 1. (Right) Drawing of type superior molar under the direction of Osborn; crown, external, and anterior views. All figures natural size.

Horizon and locality.— (Cope, p. 123) "The formation has been named the Blanco Canyon bed by Mr. Cummins (*First Annual Report of the Geol. Survey of Texas*, 1890, p. 190)." Crosby County, Texas. Type collected by W. F. Cummins.

Type and paratypes.— Univ. Texas Coll. (type cast Am. Mus. 14388). (Cope, p. 124) "This species is represented by one nearly entire superior molar of an adult, and one of a young animal, with characteristic fragments of two other superior molars, and several fragments of inferior molars. The size of the teeth is about that of the *E. occidentalis* and *E. caballus*." Measurements: (Gidley, 1907) diameters of type molar, a.p. .032, tr. .026, height of crown .060.

Type figure.— Text Fig. 134 of this Memoir.

Characters.— (Cope, p. 124) (Type and cotype) (1) Size about that of *E. caballus*. (2) Internal column [protocone] is of moderate anteroposterior extent, its posterior border marking the anterior third of the posterior lake [postfossette]; (3) its long diameter is considerably less than half that of the crown; (4) extreme simplicity of the enamel borders of the lakes; (5) pli caballin, also a crochet fold in prefossette; (6) metastyle narrowed and not flattened; (7) parastyle more flattened.

Gidley (1901, p. 124) refers this animal to *Pliohippus.*

Matthew (1913) places it in the same group as *Pliohippus nobilis* Osborn, an animal which it equals in size while it considerably exceeds *P. supremus* and *P. pernix.*

Matthew adds the following characters of the type and referred specimens (Amer. Mus. 10624) from the same formation and locality. (1) size very large, teeth comparatively elongate and narrow, and only moderately curved; (3) protocone large; (4) fossettes moderately wide; (5) enamel borders relatively simple; (6) metastylid-metaconid pillars forming a very wide column on inferior premolars, with a wide, shallow groove, which continues to base of tooth; (7) metastylid pillar flattened obliquely by the groove; (8) m_3 elongate, simple, oval; (9) mesostyle of p^2 very heavy, parastyle narrow to compressed.

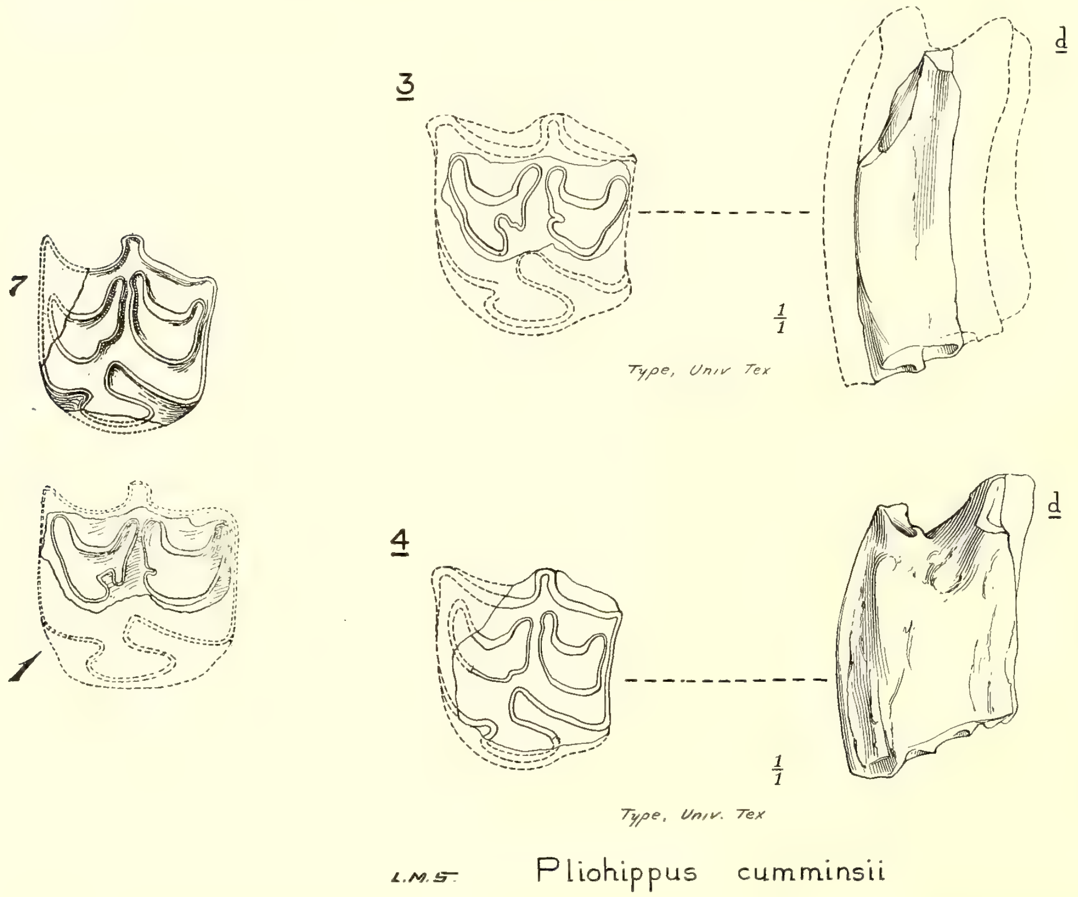


Fig. 135. Type and paratype of *Pliohippus cumminsii* Cope, Univ. Texas Coll. (type, cast Am. Mus. 14393). (7) Original figure of type. After Cope, 1893, Pl. xx, fig. 7. (1) Original figure of one of the paratypes. After Cope, 1893, Pl. xxiii, fig. 1. (3, d) Paratype, crown and posterior views, new drawing. (4, d) Type, crown and posterior views, new drawing. All figures natural size.

Pliohippus cumminsii Cope, 1893.

Plate 24.3,4. Text Fig. 135.

Equus cumminsii, Cope, Cope, Edw. D. "A Preliminary Report on the Vertebrate Paleontology of the Llano Estacado," *Fourth Ann. Rept. Geol. Surv. Texas,* (1892) 1893, p. 67, type, Pl. xx, fig. 7, paratype, Pl. xxiii, fig. 1.

Horizon and locality.— Mount Blanco, Crosby County, Texas, Blanco formation, Middle Pliocene. Name of collector not given.

Type.—Univ. Texas Coll. (cast 14393). (Cope, 1893, p. 67) "Three superior molars represent this species. They were found at different localities in the neighborhood from which we obtained the teeth of the [*Pliohippus*] *E. simplicidens*. . . . The species is named in honor of Mr. F. W. Cummins, who has done so much for the geology and paleontology of Texas." Of these isolated molars, belonging to different animals and found in different localities, the best preserved may be taken as the type. Measurements: (Cope) a.p. .024, tr. .024, length of crown .033. This fractured tooth is the left superior molar represented in Plate XX, Fig. 7. One of the paratypes is represented in Plate XXIII, Fig. 1.

Type figure.— Text Fig. 135 of this Memoir.

Characters.— (Cope, 1893, p. 67) (1) Of smaller size than the type of *Pliohippus simplicidens.* (2) Enamel borders of fossettes entirely simple [due to extreme wear]; (3) prominent convexity of the internal wall of the paracone and metacone, from which it results that the external enamel border of each fossette is deeply concave [convex]; (4) protocone with a short anteroposterior diameter as in *P. simplicidens,* not bilobate or grooved on the internal face; (5) an angle of the posterior border of the prefossette represents the loop [crochet fold]; (6) cylindric character of paracone and metacone.

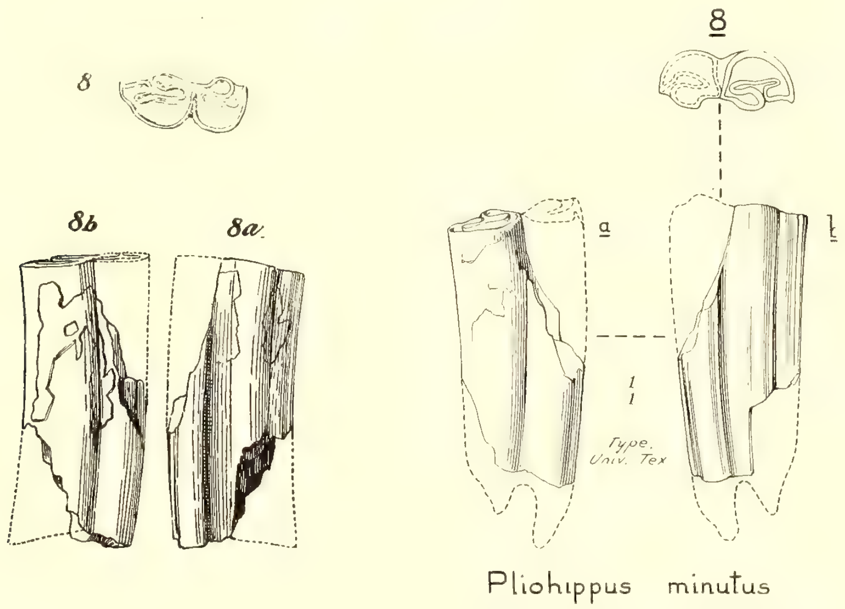


Fig. 136. Type of *Pliohippus minutus* Cope, Univ. Texas Coll. (cast Amer. Mus. 14392), ?m_2 of the right side. (Left) Original figures of the type. After Cope, 1893, Pl. xx, (8) crown view, (8*a*) internal view, (8*b*) external view. (Right) Type tooth, crown, (*a*) external, and (*b*) internal views, new drawings. All figures natural size.

Gidley (1907) observes that this type shows affinities either to *Protohippus* or *Pliohippus;* also that the greater depth of the notch anterior to the protocone suggests a somewhat more advanced form than any species of *Protohippus* from the Miocene horizon.

Pliohippus minutus Cope 1893.

Plate 33.8. Text Fig. 136.

Equus minutus, sp. nov., Cope, Cope, Edw. D. "A Preliminary Report on the Vertebrate Paleontology of the Llano Estacado," *Fourth Ann. Rept. Geol. Surv. Texas,* (1892) 1893, pp. 67–68, Pl. xx, fig. 8.

The term *Equus phlœgon* Hay was proposed (*Bull. U. S. Geol. Surv.* No. 159, 1901) to replace the term *Equus minutus* Cope, which is preoccupied.

Horizon and locality. (Cope, p. 67) " . . . from near the middle of the series from Mount Blanco." Crosby County, Texas. Middle Pliocene. Name of collector not given.

Type.— Univ. Texas Coll. (cast Am. Mus. 14392). (Cope) An inferior molar, ?m_2, of the right side. Measurements: (Cope) a.p. .0165, tr. .008, length of crown .037.

Type figure.— Text Fig. 136 of this Memoir.

Characters.— (Cope) (1) Inferior molar narrowly hypsodont; (2) investment of cement thin; (3) metaconid and metastylid appressed to hypoconid and protoconid, and spreading widely apart so as to be connected by an anteroposterior isthmus; (4) hypostylid also appressed to the hypoconid.

Gidley (1907, p. 921) regards this type as of uncertain reference with characters rather those of *Protohippus* and *Hipparion* than of *Equus*. A series of lower molars (Amer. Mus. 10626) referred by Gidley may relate this species to *Protohippus*.

Note. The type may belong to an *Hipparion* in view of the wide column and shallow gutter of inner wall.

PLIAUCHENIA-PLIOHIPPUS PROVERSUS ZONE. 18. UPPER PLIOCENE.

This zone is typified in the Upper Etchegoin of the Coalinga region of California.

Pliohippus proversus Merriam 1916.

Text Figs. 137, 138.

Pliohippus proversus, n. sp., Merriam, John C. "Relationship of Equus to Pliohippus Suggested by Characters of a New Species from the Pliocene of California," *Univ. Cal. Publ. Bull. Dept. Geology*, Vol. 9, No. 18, March 20, 1916, pp. 525–534, figs. 2, 13.

Horizon and locality.— Upper Etchegoin, Pliocene, of the North Coalinga region, western border of the San Joaquin Valley, California, locality 2079. (Merriam, p. 532) "In this connection it should be noted that the upper Etchegoin stage, in which *P. proversus* occurs, is separated from the Pleistocene horizon containing *E. occidentalis* by the Tulare formation, representing a thickness estimated by Arnold and Anderson [1] to include at least three thousand feet of strata."

Type.— Univ. Cal. Pal. Coll. 21330. A superior molar, m^1 or m^2, of the left side. Measurements: (Merriam) m^1 a.p. .030, tr. *a*.027, a.p. diameter of protocone .0138. *Paratype* and referred specimens figured but not precisely designated, from the same locality, a third superior premolar, p^3, Univ. Cal. Pal. Coll. 22328, a fourth superior premolar, p^4, 21331, an upper molar, $m^?$, 22329 (these inferior cheek teeth include premolars and molars); the astragalus and a portion of the left metacarpal.

Type figure.— Text Fig. 137 of this Memoir.

Characters.— (Merriam, 1916, p. 526) "Cheek-teeth large, long-crowned, heavily cemented. Upper cheek-teeth slightly curved; mesostyle heavy; fossettes wide to narrow, with moderately crinkled enamel borders; protocone large, strongly compressed laterally in the molars, inner border convex or nearly flat. Lower cheek-teeth with short or long parastylid; metaconid-metastylid column commonly long anteroposteriorly and narrow transversely, inner groove wide, flat as in *Equus*, or somewhat narrowed tending toward the angular form seen in *Pliohippus;* outer faces of protoconid and hypoconid either convex or somewhat flattened. Limb elements, so far as known, much like those of *Equus*. Unciform facet of metacarpal III sloping away from the plane of the magnum at approximately the angle shown in *Equus*. Lateral digits apparently much reduced distally and feet presumably monodactyle."

Merriam observes (1916) that *Pliohippus proversus* is most nearly related to *P. simplicidens* Cope and *P. cumminsii* Cope of the Blanco, Middle Pliocene, of Texas. The molars of these three species are distinguished from those of the genotype *P. pernix* Marsh by (1) straighter crowns; (2) heavier mesostyle; (3) narrowing of the fossettes; (4) protocone relatively wide transversely in the premolar region but flatter or narrower transversely in all the cheek teeth than in *P. pernix*; (5) especial resemblances of the referred lower teeth to those referred by Cope to *P. simplicidens*; (6) the crowns large, long, and heavily cemented; (7) metaconid-metastylid column wide anteroposteriorly and the internal groove broad and flat.

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[1] Arnold, Ralph, and Anderson, Robert, *U. S. Geol. Surv. Bull.* 398, 1910, p. 147.

Affinities.— (Merriam, 1916, p. 530) The resemblance of the lower cheek teeth to those of *P. simplicidens* of the Blanco may separate this species as a group distinct from the typical *Pliohippus*. There are evidences that *P. proversus* may be derived by modification from one of the early Pliocene Pacific coast species near *P. tantalus* or *P. fairbanksi*.

P. proversus shows nearest affinities among the *Equus* species to *E. occidentalis* of the California Pleistocene and to *E. stenonis* of the Old World Upper Pliocene. There is little doubt that *P. proversus* of the Etchegoin and *P. simplicidens* and *P. cumminsii* of the Blanco represent closely allied forms of nearly the same epoch. The evidence indicates that some at least of the *Equus* species of the American continent were derived from *Pliohippus* along the line of evolution passing through or near the *P. proversus* group.

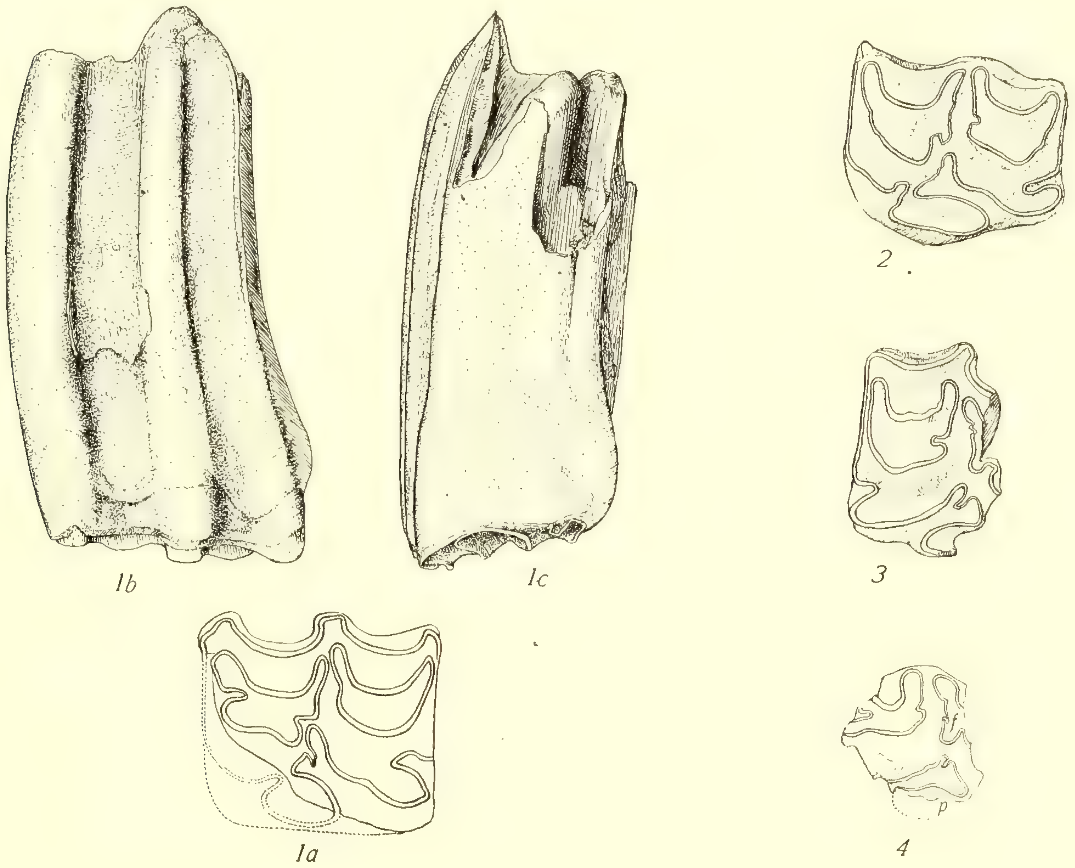

Fig. 137. Original figures of the type of *Pliohippus proversus* Merriam, Univ. Cal. Pal. Coll. 21330, m^1 or m^2, and of the upper grinding teeth of the paratype and referred specimens. (2) Occlusal view of 21330, type; (3) p^4?, occlusal view of 21331; (4) portion of an upper cheek-tooth, 22329, occlusal view; (1*a*, 1*b*, 1*c*) occlusal, outer, and posterior views of 22328, p^3?. Figures approximately natural size. After Merriam, 1916, p. 527.

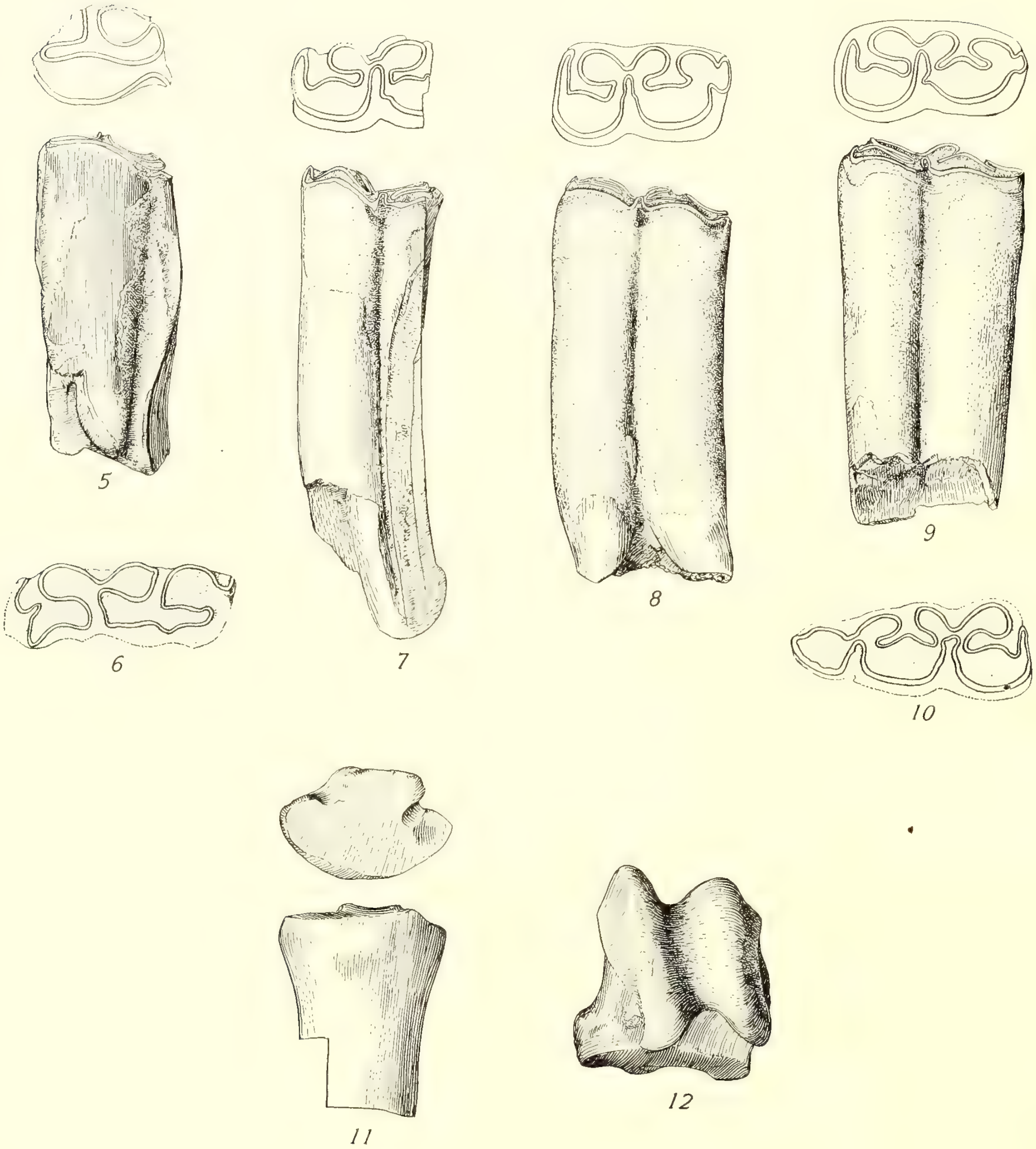

Fig. 138. (Upper) Original figures of the lower grinding teeth of paratype and referred specimens of *Pliohippus proversus* Merriam. 5. Inferior cheek tooth, No. 22316, outer and occlusal views. 6. P$_4$?, No. 21332, occlusal view. 7. Inferior molar, No. 22330, outer and occlusal views. 8. M$_1$?, No. 22312, outer and occlusal views. 9. M$_2$, No. 22314, outer and occlusal views. 10. M$_3$, No. 21333, occlusal view. Figures natural size. After Merriam, 1916, p. 529.

(Lower) Original figures of the astragalus and left metacarpal fragment of paratype of *Pliohippus proversus* Merriam. 11. Left metacarpal III, No. 22318, anterior and proximal views. 12. Astragalus, No. 22334. Both figures one-half natural size. After Merriam, 1916, p. 530.

GENUS **HIPPARION** Christol 1832.

Ann. Sci. Indust. du Midi de France, Vol. I, 1832, p. 215.

Genotype: *H. prostylum* Gervais, 1849, from the Miocene of Cucuron, Vaucluse, France.

Synonyms[1]: *Hippotherium*, Kaup, 1833, *Hipparitherium* Christol, 1847, *Neohipparion* Gidley, 1903. Genotype, *Equus* (*Hippotherium*) *gracilis* Kaup, from the Pliocene of Epplesheim. Leidy began to use the term *Hipparion* in 1856; he used *Hippotherium* in 1859. Cope used the term *Hippotherium* following Leidy's usage of 1859, 1883, 1885, etc. *Neohipparion whitneyi* of the Little White River, South Dakota, Upper Miocene, Procamelus-Hipparion zone.

Gidley (1903, p. 465) selected the superb type of *Hipparion* (*Neohipparion*) *whitneyi* as the genotype of *Neohipparion*, which in his revised diagnosis (1907, p. 924) was defined as follows: "*Generic characters.* Protocone free except at base, as in *Hipparion*. Protocone comparatively large and usually much expanded anteroposteriorly. Enamel foldings simple as compared with *Hipparion*, but usually more complex than in *Protohippus* or *Pliohippus*. So far as known the facial fossæ are never pocketed, nor are their borders sharply defined. The median external basal column present in the lower milk molars as in *Hipparion*, but shorter and much more expanded anteroposteriorly. Digits, in general, more slender than in *H. gracile*, and the lateral digits much more reduced." The genus was proposed by him to include practically all the North American species of Upper Miocene horses described by Leidy and Cope under the synonyms *Hipparion* and *Hippotherium*. Exceptions noted by the same author (1907, p. 905) are the species from Florida *H. venustum*, *H. ingenuum*, and *H. plicatile*, which resemble more closely the European *Hipparion* of the *H. gracile* type. "It seems not improbable," continues Gidley (*op. cit.*, p. 906) "that these species belonged to an American branch of the *Hipparion* group of the Old World rather than to the *Neohipparion* group more typical of this continent." In the present revision (Matthew, 1913, Osborn, 1918) it has not been found practicable to maintain a clear line of definition between species belonging to *Hipparion* and to *Neohipparion* although such clear distinction of separate phyla may be established later, in which case *Neohipparion* will resume its generic rank.

The very clearly defined and sharply circumscribed stage of equine evolution, known as *Hipparion*, was first recognized in America in 1856 when Leidy described his *Hipparion occidentale* from the Upper Miocene of the White River, South Dakota, now in the Procamelus-Hipparion zone. Since then twenty-one additional species, more or less distinct, have been named, distributed geologically through the entire Pliocene and possibly extending into early Pleistocene time in Florida. This equine type dies out in the Pliocene of Europe, but is recorded by Pomel in the early Pleistocene of Africa. It is thus believed to be more long-lived than either *Protohippus* or *Pliohippus*.

A highly distinctive character is the entire separation of the protocone as an independent column from the protoconule, a feature foreshadowed in certain species of *Merychippus*, in which the protocone is separated nearly half way down the crown. Combined with this highly special character and with the usually extreme enamel plications of the grinding teeth, is the conservative retention of the lateral digits, *Hipparion* being persistently anisotridactyl so far as this form is known at present.

The progressive evolution of *Hipparion* is especially witnessed in the elongation and plication of the crowns of the grinding teeth. The genus is certainly polyphyletic, there being positive evidence of three parallel phyla.

The characters which appear to be common to the twenty-two known species of *Hipparion* are the following:

1. Grinding teeth long, hypsodont, fully cemented, deciduous premolars short, hypsodont, fully cemented, inner basal cusp prominent (unlike *Pliohippus* in which the inner basal cusp is rudimentary or absent).
2. Protocone round-oval to flattened, completely separate to base of crown; in primitive forms giving off a spur in the direction of the protoconule; protocone enlarged, hypocone reduced, as in *Pliohippus* and *Equus*.
3. Characters of proto- and metaconules, of crochet, of hypostyle, founded on the *Merychippus* pattern.
4. Enamel borders of fossettes progressively and complexly plicated, with numerous foldings in addition to the duplication and triplication (*H. plicatile*) of the pli caballin, pli crochet, pli hypostyle, etc.
5. In the lower grinders the metastylid column widely separated from the metaconid column to the base of the crown, not fused half way down as in *Pliohippus*.

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[1] Palmer, T. S. "Index Generum Mammalium," U. S. Dept. Agric., Jan. 23, 1904, pp. 984.

I. Type Descriptions of the Species of Hipparion in Chronologic Order.

	Original name and author	Present reference	Locality	Life zone
1856	*Hipparion occidentale* Leidy	*Hipparion occidentale*	Little White River, So. Dak.	Procamelus-Hipparion zone
1859	" *venustum* Leidy	" *venustum*	Ashley River, So. Car.	Zone undetermined
1869.1.	" *affine* Leidy	" *affine*	Niobrara River, Nebr.	Procamelus-Hipparion zone
1869.2.	" *gratum* Leidy	" *gratum*	Little White River, So. Dak.	" " "
1882	*Hippotherium sinclairi* Wortman	" *sinclairi*	Cottonwood Creek, Ore.	?Pliohippus zone
1883	" *montezuma* Leidy	" *montezuma*	near Lacualtipan, Hidalgo, Mex.	" "
1885.1	" *ingenuum* Leidy	" *ingenuum*	Archer, Fla.	?Pliauchenia-Peraceras zone
1885.2.	" *peninsulatum* Cope	" *peninsulatum*	Tehuichila, Vera Cruz, Mex.	?Pliohippus zone
1886	" *rectidens* Cope	" *rectidens*	" " " "	" "
1887	" *plicatile* Leidy	" *plicatile*	Archer, Fla.	?Peraceras "
1890	" *princeps* Leidy	*Equus ?fraternus*	Peace Creek, Fla.	?Glyptotherium zone
1893.1.	*Protohippus lenticularis* Cope	*Hipparion lenticulare*	Mulberry Cañon, Good Night, Tex.	Procamelus-Hipparion zone
1893.2.	*Equus eurystylus* Cope	" *eurystyle*	" " " " "	" " "
1903	*Neohipparion whitneyi* Gidley	" *whitneyi*	Rosebud Agency, So. Dak.	" " "
1906	" *dolichops* Gidley	" *dolichops*	Little White River, Big Spring Cañon, So. Dak.	" " "
1913	*Hipparion* (?) *mohavense* Merriam	" *mohavense*	El Paso Range, So. Cal.	?Pliauchenia-Peraceras zone
1915.1.	*Neohipparion gidleyi* Merriam	" *gidleyi*	Petaluma, Cal.	?Peraceras zone
1915.2.	" *molle* Merriam	" *molle*	North Coalinga, Cal.	Pliohippus "
1915.3.	" *leptode* Merriam	" *leptode*	Thousand Creek, Nevada	Ilingoceras-Pliohippus fairbanksi zone
1915.4.	" sp. Merriam	" *platystyle*	Mt. Diablo, Cal.	?Pliauchenia-Peraceras zone
1915.5.	" *condoni* Merriam	" *condoni*	Ellensburg, Wash.	Zone undetermined
1915.6.	" *mohavense callodonte* Merriam	" *mohavense callodonte*	El Paso Range, So. Cal.	?Pliauchenia-Peraceras zone
1916.1.	*Hipparion minor* Sellards	" *minor*	Archer, Fla.	?Peraceras zone
1916.2.	" *anthonyi* Merriam	" *anthonyi*	Ironside, Malheur Co., Ore.	?Procamelus-Hipparion zone
1916.3.	*Neohipparion gratum tehonense* Merriam	" *gratum tehonense*	Tejon Hills, San Joaquin Co., Cal.	?Pliauchenia-Peraceras zone
1918	" *coloradense* Osborn	" *coloradense*	Sand Cañon, Logan Co., Col.	Procamelus-Hipparion zone

II. Types as Recorded or Inferred in 1917 in Geologic Succession.

Date	Species, Present reference	Life zone	Formation, Beds	Locality	Age
1890	*Hipparion princeps* Leidy (=*E. ?fraternus*)		Peace Creek formation	Peace Creek, Fla.	Upper Pliocene
1859	" *venustum* Leidy	Zone undetermined	Ashley River "	Ashley River, So. Car.	Pliocene
1886	" *rectidens* Cope	?Pliohippus zone	Undetermined	Lacualtipan, Hidalgo, Mex.	Pliocene
1885.2.	" *peninsulatum* Cope	" "	"	" " "	"
1883	" *montezuma* Leidy	" "	"	Tehuichila, Vera Cruz, near Lacualtipan, Hidalgo, Mex.	"
1915.3.	" *leptode* Merriam	Ilingoceras-Pliohippus fairbanksi zone	Thousand Creek formation	Thousand Creek, Nevada	Lower Middle Pliocene
1915.2.	" *molle* Merriam	Pliohippus zone	Jacalitos "	North Coalinga, Cal	" " "
1882	" *sinclairi* Wortman	?Pliohippus zone	Rattlesnake "	Cottonwood Creek, Ore.	" " "
1915.6.	" *mohavense callodonte* Merriam	?Pliauchenia-Peraceras zone	Ricardo "	El Paso Range, So. Cal.	" " "
1913	" " Merriam	" " "	" "	" " " " "	" " "
1916.1.	" *minor* Sellards	?Peraceras zone	Alachua clays, Archer formation	Archer, Fla.	?Lower Pliocene
1887	" *plicatile* Leidy	" "	" " " "	" "	" "
1885.1.	" *ingenuum* Leidy	?Pliauchenia-Peraceras zone	" " " "	" "	" "
1916.2.	" *anthonyi* Merriam	?Procamelus-Hipparion "	?	Ironside, Malheur Co., Ore.	Lower "
1916.3.	" *gratum tehonense* Merriam	?Pliauchenia-Peraceras "	Chanac formation	Tejon Hills, San Joaquin Co., Cal.	?Upper Miocene ?Early Pliocene
1915.4.	" *platystyle* Merriam	" " "	Orindan "	Mt. Diablo, Cal.	?Middle Pliocene
1915.1.	" *gidleyi* Merriam	?Peraceras zone		Petaluma, Cal.	Upper Miocene or Lower Pliocene
1893.2.	" *eurystyle* Cope	Procamelus-Hipparion zone	Clarendon formation	Mulberry Cañon, Good Night, Tex	" " " " "
1893.1.	" *lenticulare* Cope	" " "	" "	" " " " "	" " " " "
1918	" *coloradense* Osborn	" " "	Upper Pawnee Creek formation	Sand Cañon, Logan County, Col	" " " " "
1906	" *dolichops* Gidley	" " "	Little White River "	Little White River, Big Spr. Cañon, So. Dak.	" " " " "
1903	" *whitneyi* Gidley	" " "	" " " "	Rosebud Agency, So. Dak.	" " " " "
1869.2.	" *gratum* Leidy	" " "	" " " "	Little White River, So. Dak.	" " " " "
1869.1.	" *affine* Leidy	" " "	Niobrara River "	Fort Niobrara, Nebr.	" " " " "
1856	" *occidentale* Leidy	" " "	Little White River "	Little White River, So. Dak.	" " " " "
1915.5.	" *condoni* Merriam	Zone undetermined	Ellensburg formation	Ellensburg, Washington	Middle Miocene to Pliocene

6. Antero-external cingulum fold of lower teeth prominent to the crown of the tooth.

7. Crowns of the grinding teeth nearly straight, or curved (*H. lenticulare*, *H. whitneyi*).

8. Lachrymal fossa deep and sharply defined or broadly shallow, malar fossa usually absent, present in a referred *H. gratum*.

9. Limbs generally slender, feet anisotridactyl, terminal phalanges typically narrow.

The grouping of the species, partly on progressive characters, partly on true phyletic distinctions, is tentatively proposed by Gidley, Matthew, and Osborn as follows:

Group I, with elongate protocones, the *Neohipparion* of Gidley. Animals of large size.

Hipparion occidentale Leidy.
" *whitneyi* Gidley.
" *affine* Leidy.
" *sinclairi* Wortman.
" *molle* Merriam.
" *platystyle* Merriam.
" *mohavense callodonte* Merriam, etc.
" *gidleyi* Merriam (near *affine*, J. C. M.)

Group II, protocones same as in Group I. Animals of small or diminutive size, molar crowns elongate.

Hipparion gratum Leidy.
" *montezuma* Leidy.
" *peninsulatum* Cope.

Group III, protocone, as in Group I. Animals of large size, molar enamel plicate.

Hipparion plicatile Leidy.

Group IV, with round or oval protocones, as in the *H. gracile* and *H. prostylum* of Europe.

Hipparion venustum Leidy.
" *ingenuum* Leidy.
All of Florida.

This grouping is preliminary and is by no means based upon a profound study of all parts of the animal. It is probable that the skull structure, the preorbital fossæ, and possibly divergencies of foot structure will have to be considered in separating the phyla of *Hipparion*. At present our knowledge of the foot structure and even of the skull structure is very incomplete.

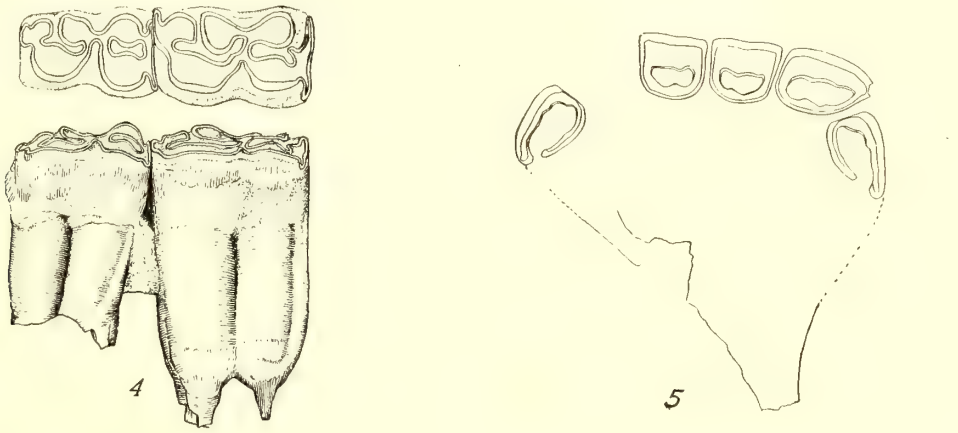


Fig. 139. (Left) Original figure of the type of *Hipparion condoni* Merriam, Univ. Oregon Coll. 672, p_4, m_1. Outer and occlusal views, fig. 4, p. 6. (Right) Referred mandibular symphysis of *Hipparion condoni*, Univ. Oregon Coll. 668, fig. 5, p. 6. All figures natural size. After Merriam, 1915.

Hipparion condoni Merriam 1915.

Text Fig. 139.

Hipparion condoni, n. sp., Merriam, John C. "New Species of the Hipparion Group from the Pacific Coast and Great Basin Provinces of North America," *Univ. Cal. Publ. Bull. Dept. Geol.* Vol. 9, No. 1, June 29, 1915, p. 6, fig. 4.

Horizon and locality.— Ellensburg formation, Kittitas County, Washington. Middle to Upper Miocene. Type collected by Professor Thomas Condon.

Type.— Univ. Oregon Coll. 672. Two lower grinding teeth, p_4, m_1. Measurements: p_4 a.p. .021, tr. .0111, metaconid-metastylid column .0126, height of crown, .031; m_1 a.p. .0176, tr. .0103, metaconid-metastylid column a.p. .0112.

Type figure.— Text Fig. 139 of this Memoir.

Characters.— (Merriam) (1) Length of crowns similar to advanced stages of *Merychippus;* (2) heavily cemented; (3) metaconid-metastylid column more elongate anteroposteriorly than in any *Merychippus* form known; (4) wide and flat internal groove between metaconid and metastylid, typical of *Hipparion;* (5) parastylid extends inward as far as metaconid; (6) a sharp anteroexternal ridge developed on protoconid.

Merriam observes that the open portions of the internal valleys correspond approximately with those seen in *Hipparion,* and that the progressive stage seems rather that of *Hipparion* than of *Merychippus.*

A referred specimen is Univ. Oregon Coll. 668, the extremity of a lower jaw containing the lower incisors.

PROCAMELUS-HIPPARION ZONE. 13. LOWER PLIOCENE.

THIS ZONE IS TYPIFIED IN THE FORT NIOBRARA, NEBRASKA, AND THE LITTLE WHITE RIVER OF NEBRASKA AND DAKOTA.

Hipparion occidentale Leidy 1856.

Plates 25.9, 34.5. Text Fig. 140.

Hipparion occidentale, Leidy. "Notices of some remains of extinct Mammalia, recently discovered by Dr. F. V. Hayden, in the bad lands of Nebraska," *Proc. Acad. Nat. Sci. Phila.* Vol. VIII, No. 1, 1856, p. 59, no figure. "The Extinct Mammalian Fauna of Dakota and Nebraska," *Jour. Acad. Nat. Sci. Phila.* (2) Vol. VII, 1869, pp. 281–282, Pl. xviii, figs. 1–5.

Horizon and locality.— (Leidy, 1856.) "....the White River of Nebraska." (1869, p. 281) "....the Mauvaises Terres of White River, Dakota....According to Dr. Hayden, they belong to the superficial portion of the tertiary deposits, or bed F of the section, as indicated on p. 16, and which is more fully developed on the Niobrara River and at Bijou Hill." Type collected by F. V. Hayden. (Gidley, 1907) Little White River, South Dakota, "Nebraska formation," Lower Pliocene.

Type.— Acad. Nat. Sci. Phila. Coll. (Leidy, 1869, p. 281) "The teeth consist of four upper molars of the right, and one of the left side, and are represented in figures 1–5, plate XVIII. They were accompanied by a fragment of a last upper molar and a lower molar, apparently of another equine animal. The specimens are between a third and a half worn away, and exhibit on their triturating surface the characters usually ascribed to the genus." (Gidley, 1907, p. 877) Four upper teeth apparently of a single individual (right) p^2, p^3, and m^2, and (left) p^3, No. 3, Acad. Nat. Sci. Phila. Coll., cast Amer. Mus. 10794. Measurements, (Gidley, 1907) p^2 a.p. .0315, tr. .0235; p^3 a.p. .0265, tr. .025; m^2 .023, tr. .022; a.p. diameters of protocones, p^2 .008, p^3 .010, m^2 .008.

Type figure.— Text Fig. 140 of this Memoir.

Characters.— (Leidy, 1856, 1869, Gidley, 1907) (1) Protocone isolated, elliptical, anteroposterior diameter twice as great as transverse; (2) protoconule, metaconule, and fossette borders of upper grinders comparatively complicated but less so than in European types; (3) hypocone small, about one-half the size of the protocone; (4) upper premolars relatively elongate anteroposteriorly; (5) upper molars compared with premolars comparatively small; (6) tooth crowns long and slightly curved; (7) protocone of uniform width throughout its length; (8) a much larger animal than *Hipparion venustum* of South Carolina, approaching the *H. gracile* of Europe, and resembling in size, proportions, and curvature the teeth of *Equus asinus.*

A referred specimen is Amer. Mus. 10579.

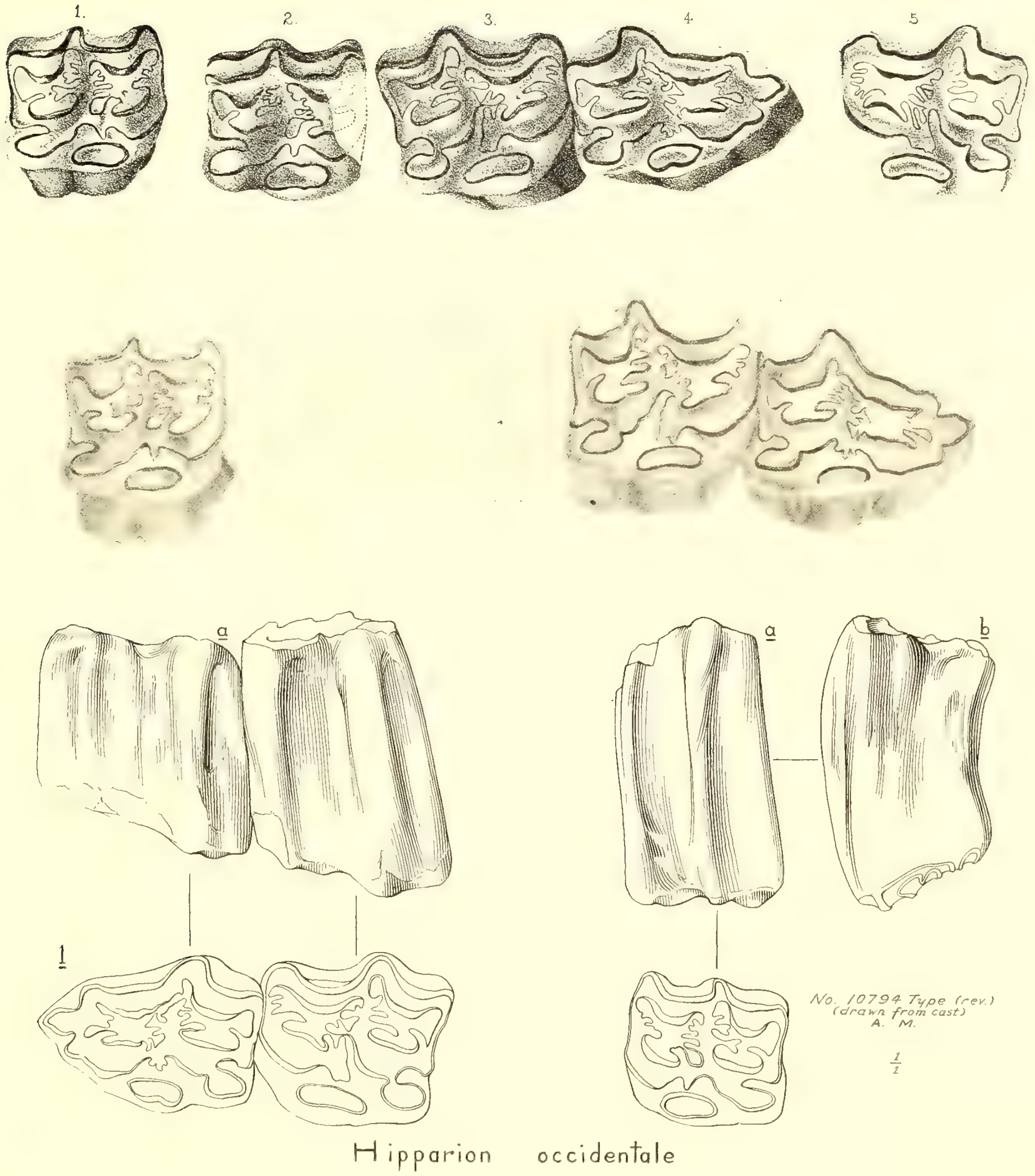


Fig. 140. Type of *Hipparion occidentale* Leidy, Acad. Nat. Sci. Phila. Coll. (cast Amer. Mus. 10794). (Top) Original figures of type. After Leidy, Pl. xviii, figs. 1–5; fig. 1, r. m^2, fig. 3, r. p^3, fig. 4, r. p^2, fig. 5, l. p^3. (Middle) Crown view of p^2, p^3, m^2, redrawn under the direction of Osborn by S. Oka. (Lower) Crown and external views of p^2, p^3, m^2, drawn from cast under the direction of Osborn, reversed in drawing. All figures natural size.

Hipparion affine Leidy 1869.

Text Fig. 141.

Hipparion affine, Leidy, Joseph. "The Extinct Mammalian Fauna of Dakota and Nebraska," *Jour. Acad. Nat. Sci. Phila.* (2) Vol. VII, 1869, p. 286, Pl. xviii, figs. 20–23.

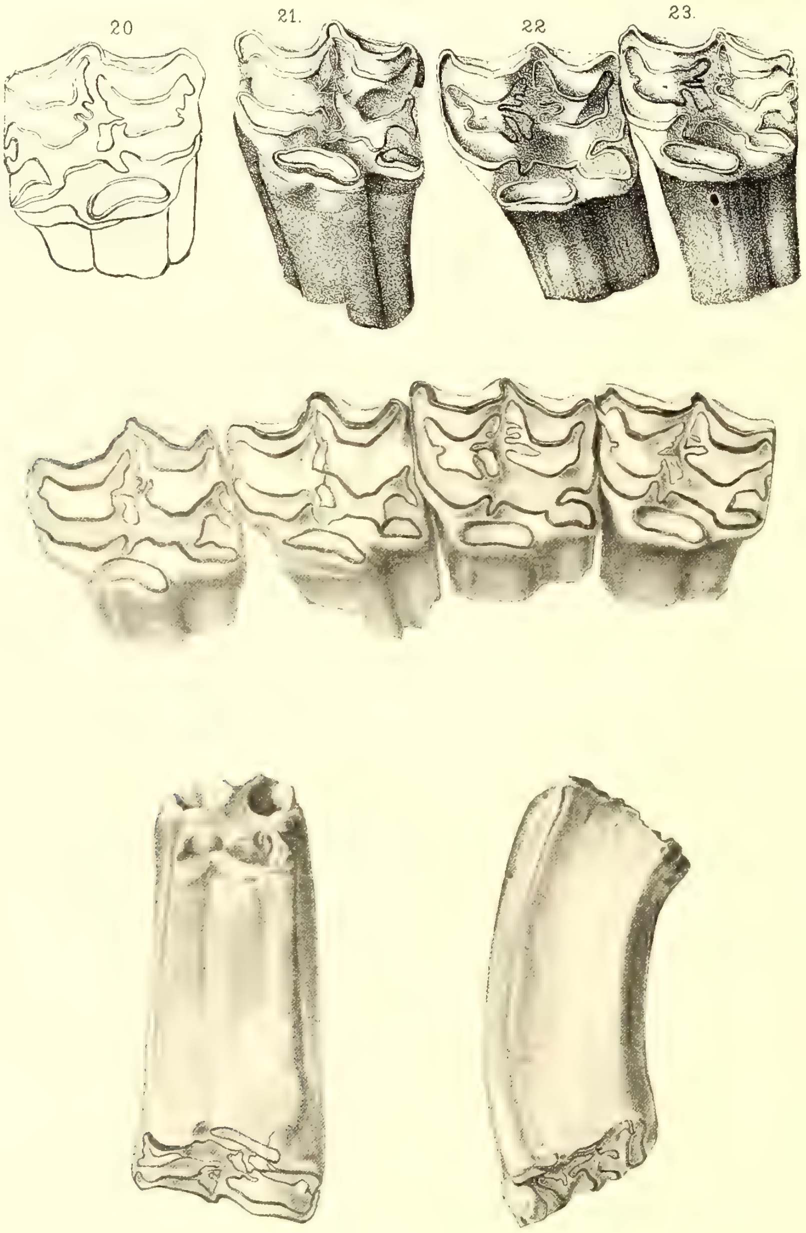


Fig. 141. (Upper) Original figures of the type of *Hipparion affine* Leidy, U. S. Nat. Mus. 584, p^2, p^3, m^2. After Leidy, 1869, Pl. xviii, figs. 20–23. Natural size. (Middle) Type upper molars, redrawn under direction of Osborn, by S. Oka, partly reversed in drawing; crown view of $?p^{2,3}$ of the right side, reversed in drawing, p^3, m^2 of the left side. (Lower) Internal and anterior views of an isolated type molar.

Horizon and locality.— (Leidy) " . . . . from the Niobrara River." (Gidley, 1907) Niobrara River near Fort Niobrara, Nebraska. Nebraska formation, Procamelus, Hipparion zone, Upper Miocene. Name of collector not given.

Type.— U. S. Nat. Mus. 584. (Leidy) "1. Five upper molars, apparently from the same individual, consisting of the second and third of the right side, and the third, fourth and fifth of the left side. A series, exhibiting the triturating surfaces, from the second to the fifth inclusive, is represented in figures 20–23 [pl. XVIII]." (Gidley, 1907) Five uppermolars of one individual; left m^1, m^2, p^4, and right p^4, p^3.

Measurements (Gidley, 1907, p. 888):

Diameters of p^3,	anteropost. .026	transv.	.023
" " p^4,	" .025	"	.022
" " m^1,	" .024	"	.022
" " m^2,	" .0235	"	.019
" " m^2, at middle of crown	.0215	"	.0215
Height of crown of m^2 (outside)			.058

Type figure.— Text Fig. 141 of this Memoir.

Characters.— (Leidy, 1869) (1) An animal of larger size than the type of *Hippodon speciosum*, about the size and proportions of *Hipparion occidentale* or the existing *Equus asinus*. (2) Molars differing from those of *H. occidentale* in the simple enamel plications, which are not more folded than in the horse. (Leidy, p. 286) Type a younger individual than the type of *H. occidentale*, the molars comparatively little worn; m^2 not sufficiently worn to exhibit the inner enamel plications. Internal enamel column [protocone] proportionately wider than in *Hippodon speciosum* and absolutely wider than in *Hipparion occidentale*. (Matthew, 1913) (1) Protocone wide and flattened, oval from summit to base; (2) fossette borders with a few large plications, in little worn stage simple, with folds inconspicuous in half worn stage; (3) pli caballin persists in half worn teeth.

Matthew refers to this species Amer. Mus. 8362, a series of upper premolars and molars about half worn, from the Republican River, Rawlins County, Kansas.

Hipparion gratum Leidy 1869.

Plate 32.3. Text Figs. 142, 143.

Hipparion gratum. Leidy, Joseph. "The Extinct Mammalian Fauna of Dakota and Nebraska," *Jour. Acad. Nat. Sci. Phila.* (2) Vol. VII, 1869, pp. 287–288, Pl. xviii, fig. 25.

Horizon and locality.— (Leidy) ". . . . in the Niobrara collection." Gidley remarks (1906, p. 146) "The type tooth, with a few other isolated upper teeth, reported by Leidy from the Little White River locality, have hitherto represented all that was known of this species." Name of collector not given.

Type and paratype.— U. S. Nat. Mus. 587. (Leidy, Gidley, 1907, p. 888) A right upper premolar, p^2, associated with two others, ?m^2 and m^3. Measurements: (Type, Gidley, 1907) p^2 a.p. .0215, tr. .0175, height of partially worn crown .031.

Neotype.— (Gidley, 1907, p. 888) Amer. Mus. 10863, anterior portion of a skull containing complete dentition of the left side, from the Nebraska formation, Upper Miocene, Little White River.

Type figure.— Text Fig. 142 (25, 26) of this Memoir.

Characters.— Type. (Leidy, 1869) (1) Second superior premolar (fig. 25, pl. XVIII) closely resembles that of *Protohippus placidus* in size, form, and proportions; (2) fossettes less gaping than in *P. placidus;* (3) enamel more plicate. *Type and neotype.* (Gidley, 1907) (4) Protocone usually small, elliptical in cross section, separate from protoconule to base of crown; (5) anterior border of prefossette plicated in the premolars, a character not observed in *Protohippus.* (6) Lachrymal and malar fossæ moderately deep, limited in area; (7) anterior palatal foramina opening backward into long, narrow slits, as in the modern horse; (8) palate strongly concave, especially anteriorly; (9) nasals short-tipped, but very broad where they join the premaxillaries; (10) lower jaws short and deep as in *P. placidus*, but symphysis long and extension beyond premolars comparatively shorter; (11) angle of jaw proportionately smaller, lower border of ramus more curved and bowed.

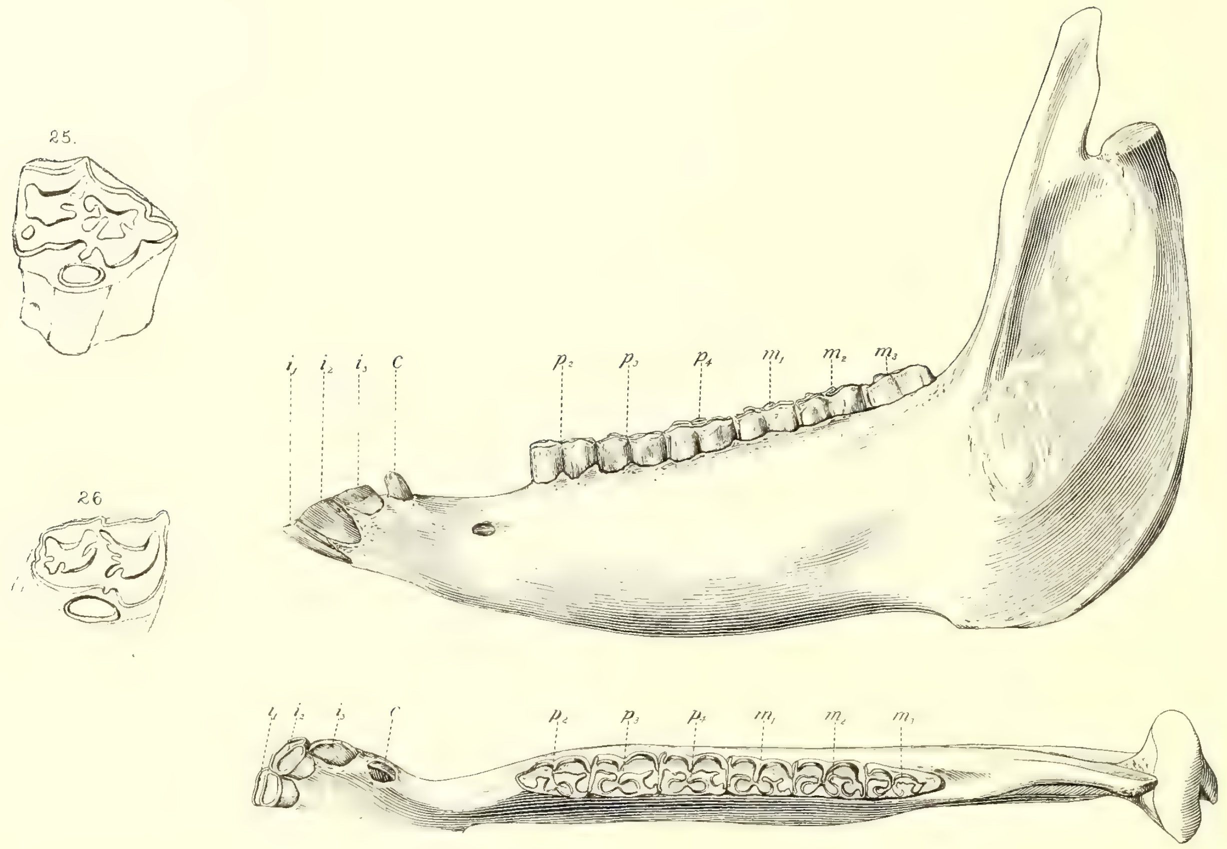


Fig. 142. Original figure (25) of the type second superior molar of the right side of *Hipparion gratum* Leidy, U. S. Nat. Mus. 587. After Leidy, 1869, Pl. xviii, fig. 25. (26) Original figure of a paratype. After Leidy, 1869, Pl. xviii, fig. 26. Both figures natural size. (Right) Side and crown views of jaw referred by Gidley to *H. gratum* Leidy, Amer. Mus. 10845. After Gidley, 1906, figs. 6, 7, p. 141. One-half natural size.

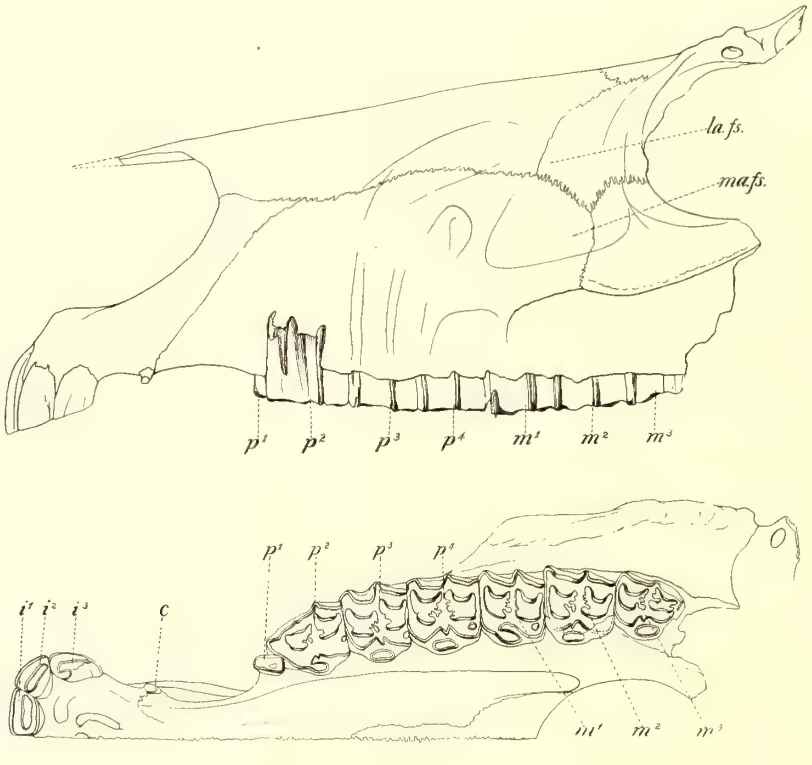


Fig. 143. Original figures of the neotype (Gidley) of *Hipparion gratum* Leidy, Amer. Mus. 10863. (Upper) Facial portion of skull, side view; *ls. fs.* lachrymal fossa, *ma. fs.* malar fossa, fig. 10, p. 145. (Lower) Palatal view of the facial portion of the skull, fig. 11, p. 146. Both figures one-half natural size. After Gidley, 1906.

Hipparion whitneyi Gidley 1903.

Plates 31.1,2, 32.1, 39.1,4, 51.3,6, Text Figs. 51, 144.

Neohipparion whitneyi, gen. et sp. nov. Gidley, J. W. "A New Three-Toed Horse," *Bull. Amer. Mus. Nat. Hist.* Vol. XIX, Art. XIII, July 24, 1903, pp. 467–476, no figure. Osborn, Henry Fairfield, "Ten Years' Progress in the Mammalian Palæontology of North America," *Comptes rendus du 6me Congrès intern. de Zoologie* (*Session de Berne*, 1904) May 25, 1905, Pl. xi.

Horizon and locality.— (Gidley) Little White River, near the Rosebud Indian Agency, South Dakota, Nebraska formation, Lower Pliocene. Type discovered by H. F. Wells, collected by J. W. Gidley of the American Museum expedition of 1902.

Type.— Amer. Mus. 9815. A complete skull and skeleton of an adult female individual immediately associated with incomplete skeletons of five other individuals, immature, undoubtedly belonging to the same species. Measurements: (Gidley, 1907).

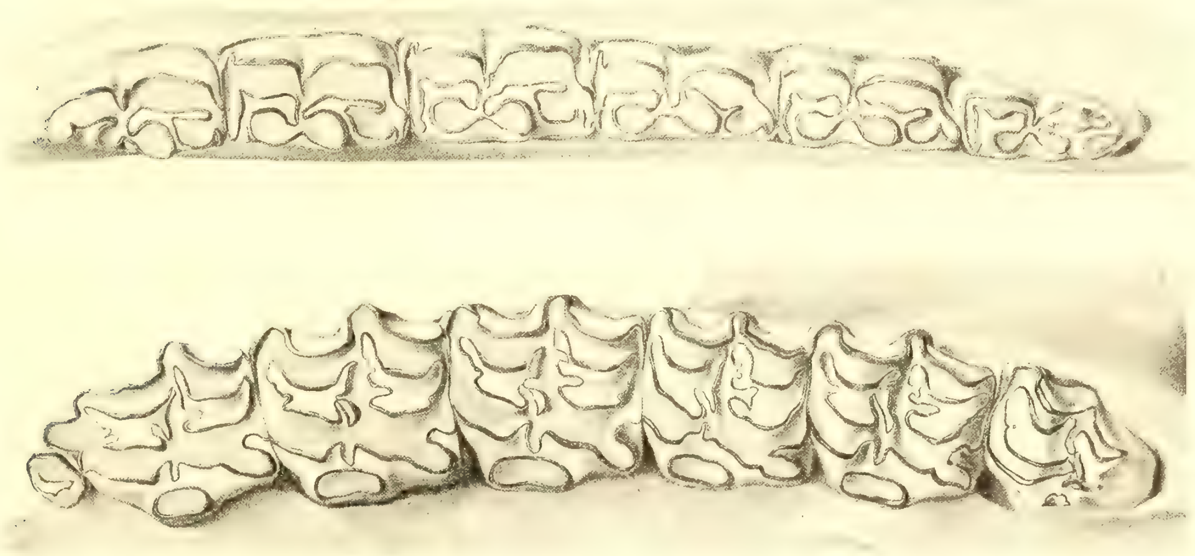


Fig. 144. *Hipparion whitneyi* Gidley, Amer. Mus. 9815. Crown view of the upper and lower grinding teeth of the type. Natural size. Drawings by S. Oka.

Measurements (in part)

Diameters of p^1, anteropost.	.095	transv.	.007
" " p^2, "	.0295	"	.0235
" " p^3, "	.025	"	.025
" " p^4, "	.025	"	.0255
" " m^1, "	.022	"	.023
" " m^2, "	.024	"	.023
Total length of series	.152		
Width across external incisors	.055		

Type figure. Plates 51, text Figs. 51, 144 of this Memoir.

Characters.— (Gidley, 1907, p. 924) (1) Size about equal to *Hipparion occidentale*, but enamel foldings much more simple, even more simple than in *H. affine*; (2) *H. whitneyi* further differs from *H. affine* in the much stronger development of the styles of the ectoloph; (3) protocone relatively large and very much elongated in cross section anteroposteriorly; (4) inner, or lingual, wall of the protocone flat and slightly depressed, as is usual in *Equus caballus*. (5) Metapodials very long and slender; (6) lateral digits greatly reduced, their terminal phalanges not extending to the distal end of the first phalanx of the median digit.

A referred specimen is Amer. Mus. 9817.

Hipparion dolichops Gidley, 1906.

Text Fig. 145.

Neohipparion dolichops sp. nov., Matthew, W. D. and Gidley, J. W. "New or Little Known Mammals from the Miocene of South Dakota," *Bull. Amer. Mus. Nat. Hist.*, Vol. XXII, Art. VIII, May 26, 1906, pp. 148–149, fig. 14.

Horizon and locality.— Big Spring Cañon, headwaters of the Little White River, South Dakota, "Nebraska formation," Lower Pliocene. Type collected by J. W. Gidley of the American expedition of 1903.

Type.— Amer. Mus. 10865. A portion of the right maxillary containing the molariform cheek teeth from p^2–m^2 inclusive. Measurements: (Gidley, 1907).

Measurements of Type (Amer. Mus. 10865)

Diameters of p^2, anteropost.	.030	transv.	.022
" " p^3, "	.023	"	.0235
" " p^1, "	.0235	"	.023+
" " m^1, "	.020	"	.022
" " m^2, "	.020	"	.0215

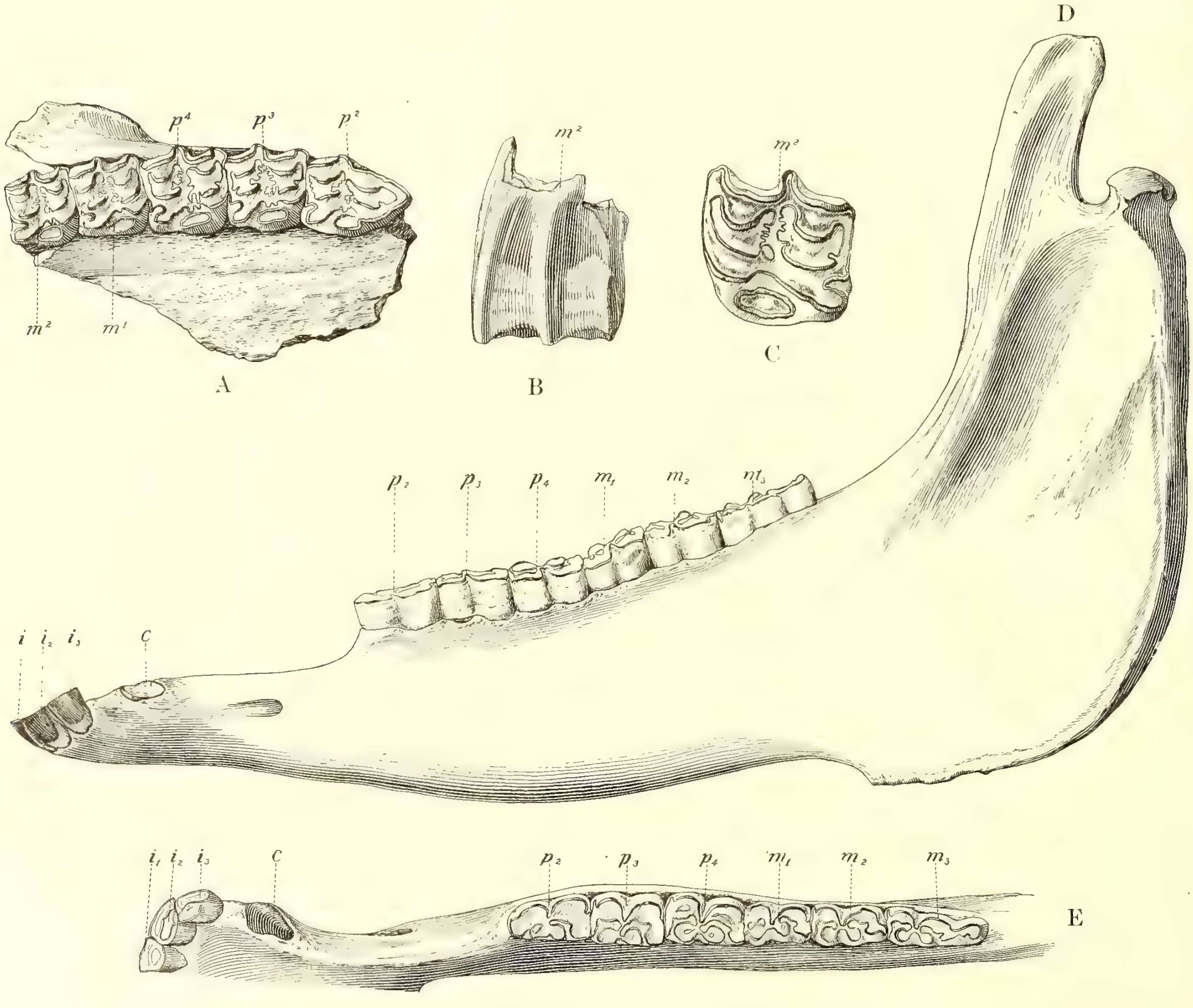


Fig. 145. *Hipparion dolichops* Gidley, Am. Mus. 10865. (A) Original figure of the type, p^2–m^2, fig. 14, p. 149. (B, C) Side and crown view of m^2 of a paratype, Am. Mus. 10832, figs. 15, p. 149. (D, E) Side and palatal views of the left lower jaw of the same paratype, Am. Mus. 10832, figs. 16, 17, pp. 150, 151. A, D, E One-half natural size. B, C Natural size. After Gidley, 1906.

Paratype.— (Gidley, 1906, pp. 148–151) Amer. Mus. 10832. Complete lower jaws with full dentition and an associated upper molar, m^2. Measurements: (Gidley, 1906, p. 151).

Measurements of Paratype (Amer. Mus. 10832)

Diameters of m^2, anteropost.	.021	transv.	.021
Total length of jaw	.352		
" " " molar-premolar series	.138		

Type figure.— Text Fig. 145 of this Memoir.

Characters.— (Gidley, 1906, 1907) (1) About equal in size to *Hipparion affine* Leidy; (2) differing from *H. affine* in (a) the more open fossettes of the upper teeth, (b) the greater complexity of the enamel foldings, (c) the proportionately smaller and more rounded protocones; (3) differing from *H. occidentale* Leidy in (a) its smaller size, and (b) in the different proportions of the premolars, which are relatively broader transversely; (4) differing from *H. whitneyi* Gidley in (a) its smaller size, (b) in the greater number of folds in the enamel walls of the metaloph in the upper teeth, (c) the more open fossettes, (d) the more rounded form of the protocones, (e) in the extreme forward position of the infraorbital foramen, which is placed directly above the space between p^2 and p^3, while (f) the masseter ridge extends but little farther forward than in *H. whitneyi.* (5) The jaw is much longer and more slender than in *H. whitneyi* or in other known Miocene species of horse; (6) the preorbital portion of the skull also is proportionately longer than the average of a dozen specimens of *Equus caballus* examined by the author.

Hipparion coloradense sp. nov.

Text Fig. 146.

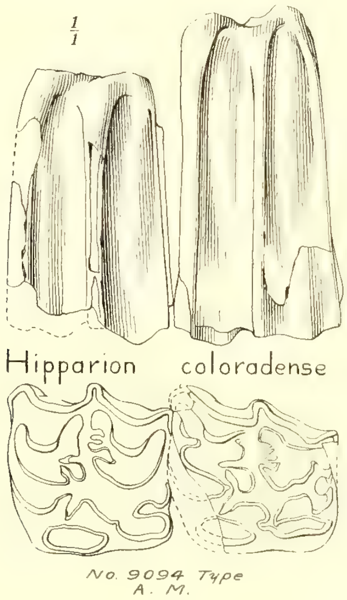


Fig. 146. *Hipparion coloradense* Osborn, Amer. Mus. 9094, superior grinding teeth of the type, m^1, m^2 of the left side (reversed in drawing). Natural size.

Horizon and locality.— Sand Cañon, head of Pawnee Creek, Upper Pawnee Creek beds, Logan County, Colorado. Procamelus-Hipparion zone, Lower Pliocene. Type collected by Maxwell of the American Museum expedition of 1898.

Type.— Amer. Mus. 9094. Upper grinding teeth, m$^{1-2}$, of the left side, ulna, radius, and hind foot.

Referred specimens, Amer. Mus. 9115b, portion of hind foot, Amer. Mus. 9098, upper and lower teeth from Sand Cañon, Pawnee Creek, upper Pawnee Creek beds, Amer. Mus. 9384, lower jaw, from ten miles west of Grover, Colorado.

Type figure.— Text Fig. 146 of this Memoir.

The type and referred specimens were found associated with *Protohippus proplacidus* and *Pliohippus* (Am. Mus. 9093) from the same locality. The third referred specimen (Am. Mus. 9384), from near Grover, was found in the level of *Teleoceras medicornutus.*

Characters.— Matthew (1913) (1) Size large to medium. (2) Upper molars long-crowned, moderately curved, mesostyle heavy, narrowing slowly toward summit of crown; (3) protocones separate except at base of crown; (4) protocone large, strongly flattened, fossette borders considerably infolded, fossettes contracted; (5) pli caballin strong, (6) metastylid on p_2 widely separated from metaconid; (7) metastylid-metaconid column broad, deeply grooved to base of tooth; (8) outer surface of protoconid and metaconid considerably flattened; (9) anterior cingulum a prominent plate on internal and external sides of lower teeth, expanding toward crown; (10) lower incisors large, preorbital region moderately elongate. (11) Ulnar shaft greatly reduced, slender, thread-like toward middle, distal half unknown; (12) metapodials long, lateral digits much reduced; (13) a facet on Mts. III for mesocuneiform. This character is otherwise unknown in the *Hipparion* of America and belongs to *Pliohippus* and the *Hipparion* of Europe.

Hipparion lenticulare Cope 1893.

Plates 32.2, 33.5,6,7. Text Figs. 147, 148 148a.

Protohippus lenticularis, Cope, Cope, Edw. D. "A Preliminary Report on the Vertebrate Paleontology of the Llano Estacado," *Fourth Ann. Rept. Geol. Surv. Texas* (1892) 1893, pp. 41–42, Pl. xii, figs. 1, 2, 2a.

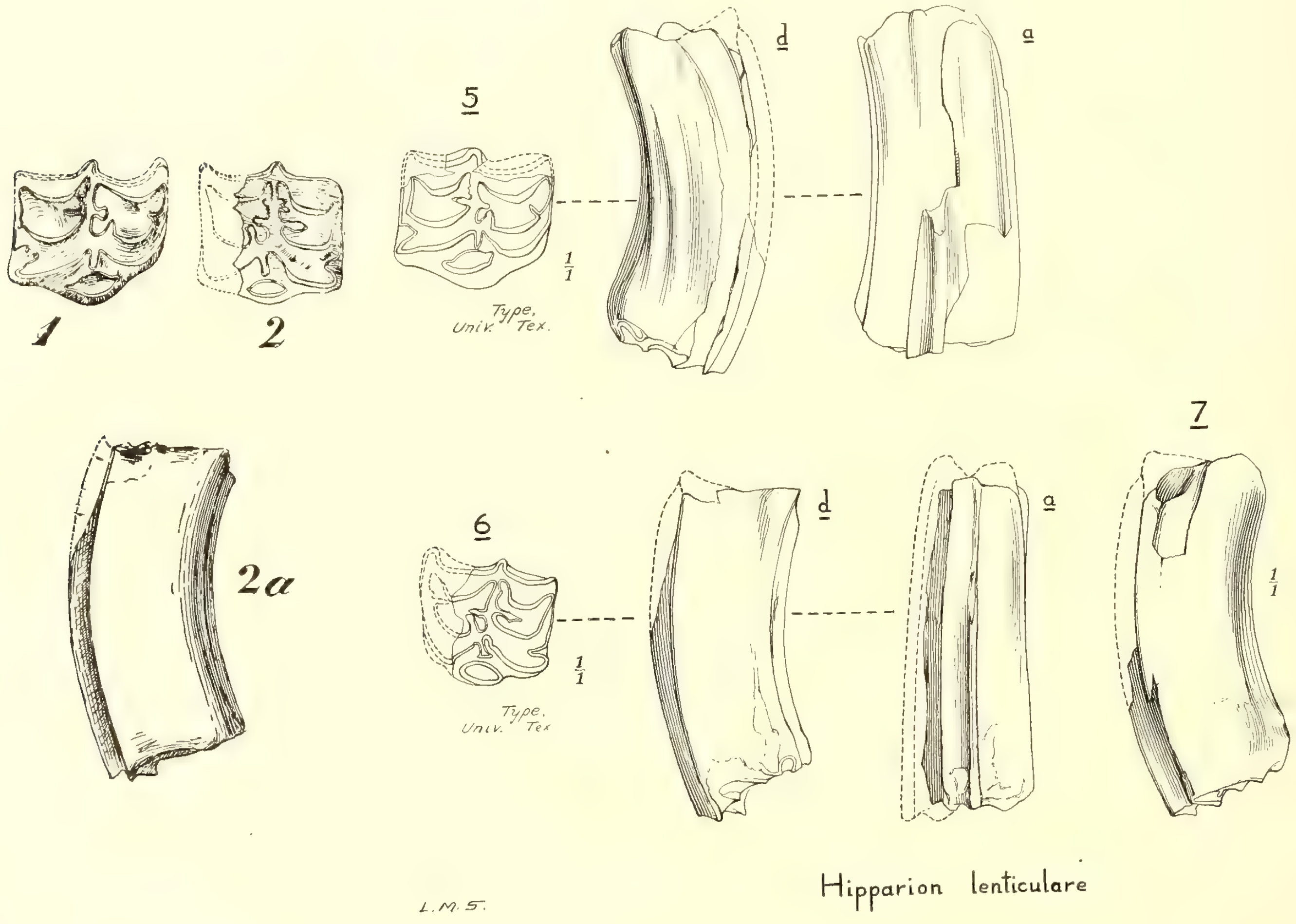


Fig. 147. (Left) Original figures of the type superior molars of *Hipparion lenticulare* Cope, Univ. Texas Coll. (cast Amer. Mus. 14390). (1, 2) Crown view in an early stage of wear; (*2a*) posterior side of the tooth represented in fig. 2. After Cope, 1889, Pl. xii, figs. 1, 2, *2a*. (5, 6, 7) The same teeth redrawn under the direction of Osborn. (5) Right superior molar of the type, (6) paratype left superior molar, (7) posterior view of the paratype tooth. All figures natural size.

Horizon and locality.— (Cope) Mulberry Cañon, near Goodnight, Texas. Clarendon formation ("Goodnight beds"). Type collected by F. A. Cummins.

Type.— Univ. Texas Coll. (cast Am. Mus. 14390). (Cope) Two isolated superior molar teeth, obviously belonging to different individuals: No. 1 (type) a right superior molar, diameters a.p. .021, tr. .019, height of crown .048; No. 2, a left superior molar, fractured anteriorly, diameters a.p. .021, tr. .018, height of crown .044. *Neotype* (Gidley, 1907, p. 916), Amer. Mus. 10584, anterior portion of skull with full dentition from the Clarendon beds of Donley County, Texas.

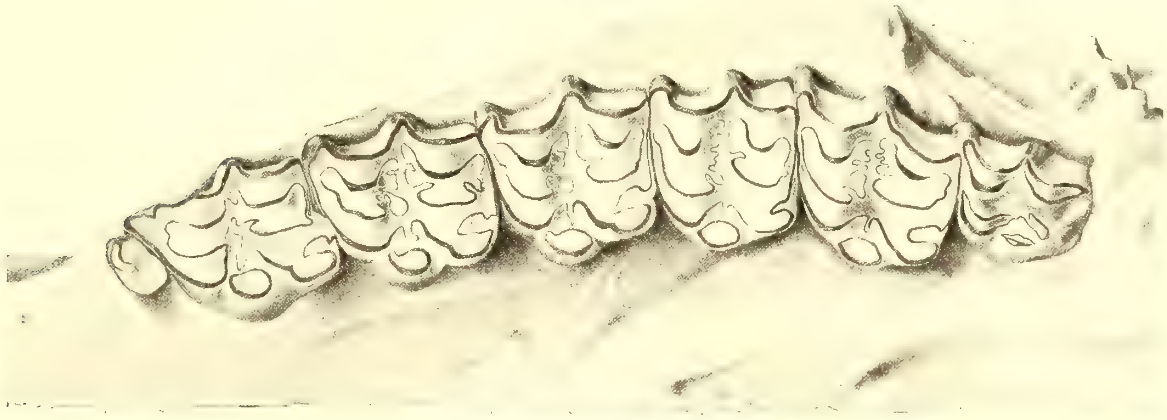


Fig. 148. Neotype (Gidley) of *Hipparion lenticulare* Cope, Amer. Mus. 10584. Natural size. Drawing by S. Oka.

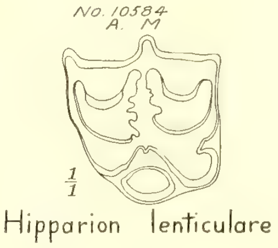


Fig. 148*a*. Section of crown of the neotype of *Hipparion lenticulare* Cope, Amer. Mus. 10584, p^4. To show pattern of the half-worn grinding tooth.

Type figure.— Text Fig. 147 of this Memoir.

Characters.— (Cope, 1893, Gidley, 1907) (1) Distinguished by the absolutely lenticular section of the protocone, which presents acute angles anteriorly and posteriorly and convex surfaces internally and externally; (2) enamel borders of fossettes moderately complex [relatively simple], in type only three folds projecting into prefossette and three folds [in paratype] into postfossette; (3) crown quite strongly curved transversely. (4) An animal about the size of *Hippodon speciosus* Leidy.

Gidley observes that the sharply lenticulate form of protocone, pointed out by Cope as distinctive of the species, is apparently due entirely to the little worn condition of the tooth crown. The simple enamel foldings in the fossettes relate this species to the *Hipparion whitneyi* type and to the referred specimen Amer. Mus. 10584 obtained by Gidley in 1889 from the Clarendon beds of Donley County, Texas.

Neotype characters.— (Gidley) (1) Corresponding teeth nearly identical in size with those of the type molars, protocones of the less worn teeth, m$^{1-2}$, lenticulate in form, while the others, p$^{2-4}$, have a suboval outline with a spur extending off anteriorly toward the convex apex of the protoconule, indicating that Cope was correct in referring this animal to *Protohippus;* (2) in skull characters the palate high-arched, the muzzle comparatively long and slender, the cranium as compared with that of *Protohippus perditus* with a considerable vertical depth; (3) in the facial region, the lachrymal fossa especially well developed, sharply defined, and deeply pocketed posteriorly; (4) no trace of malar fossa.

Hipparion eurystyle Cope 1893 *spec. indet.*

Plate 33.1,2,3,4. Text Fig 149.

Equus eurystylus, Cope, Cope, Edw. D "A Preliminary Report on the Vertebrate Paleontology of the Llano Estacado," *Fourth Ann. Rept. Geol. Surv. Texas* (1892) 1893, pp 43–45, type Pl. xx, figs. 6–6a, paratype Pl. xii, figs. 7–8b.

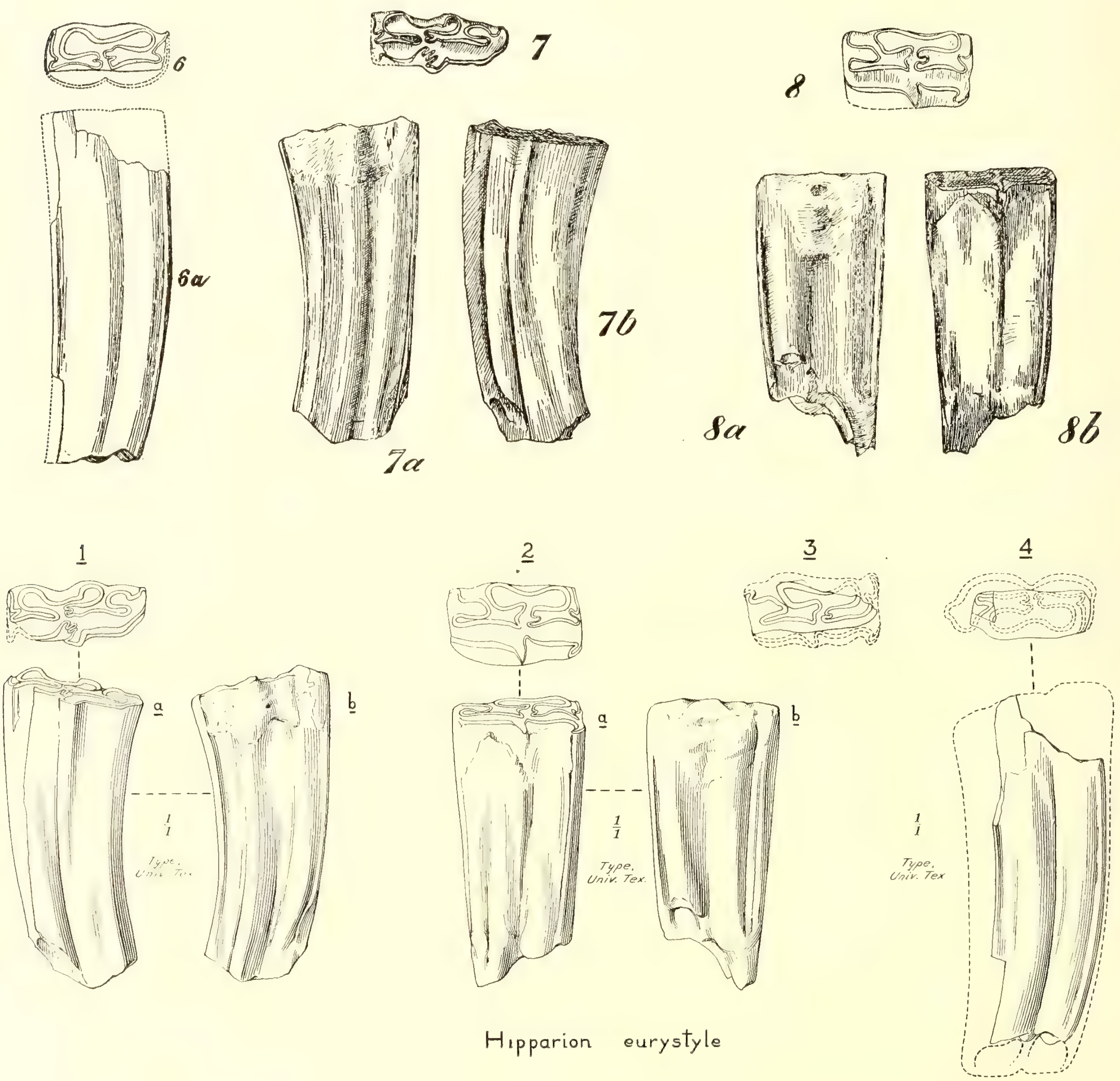


Fig. 149. (Upper) Original figures of the type and paratypes of *Hipparion eurystyle* Cope, Univ. of Texas Coll. (cast Am. Mus. 14391). After Cope, 1893; type, Pl. xx, figs. 6, 6*a*, paratypes, Pl. xii, figs. 7–8*b*. All figures natural size.

(Lower) The same teeth redrawn under the direction of Osborn. Fig. 4 corresponds to the specimen first mentioned by Cope (his 6, 6*a*). All figures natural size.

Horizon and locality. (Cope) Type locality, Palo Duro Cañon, Crosby County, Texas; paratype locality Mulberry Cañon near Goodnight, Texas, Clarendon formation ("Goodnight beds"), Upper Miocene. Type collected by F. W. Cummins.

Type.—Univ. Texas Coll. (cast Am. Mus. 14391). (Cope) A broken lower molar. Measurements: (Cope, p. 44) a. p. diameter of crown at middle .020, transverse width of crown restored .011, a.p. diameter of metaconid-metastylid column .013. *Paratypes*: four inferior molars (molars and premolars) from Mulberry Cañon near Goodnight Ranch, Texas, represented in Plate XII, Figs. 8, 8a, 8b.

Type figure.— Text Figs. 149 of this Memoir.

Characters. (Cope) (1) Of small size. (2) Relative great width of the metaconid-metastylid column; (3) close appression of this column to the protoconid and hypoconid. (For further description see Cope, *op. cit.*)

Gidley observes (1907, p. 918) that the type tooth is so fragmentary as to show no particularly distinctive features.

The type is, in fact, indeterminate. The characters derived from the paratypes are invalid because certain of them (such as the teeth represented in Cope, plate XII, 7, 7a, 8, 8a) certainly belong to other species.

The type teeth may be identified with the genus *Hipparion;* the species is wholly indeterminate.

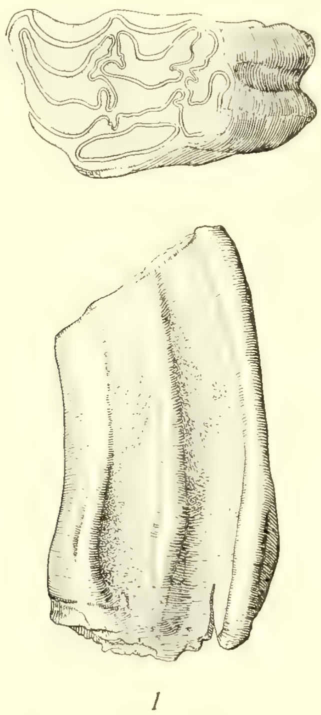


Fig. 150. Original figures of the type of *Hipparion gidleyi* Merriam, Univ. Cal. Pal. Coll. 21382, m^3. External and crown views. Natural size. After Merriam, 1915, fig. 1, p. 2.

Hipparion gidleyi Merriam 1915.

Text Fig. 150.

Neohipparion gidleyi, n. sp., Merriam, John C. "New Species of the Hipparion Group from the Pacific Coast and Great Basin Provinces of North America," *Univ. Cal. Publ. Bull. Dept. Geol.* Vol. 9, No. 1, June 29, 1915, pp. 1–2, fig. 1.

Horizon and locality.— (Merriam) "Probably from a stratum just below the coal seam at a mine on the Lawler Ranch, six miles east of Petaluma, California. The formation has been doubtfully referred to the San Pablo Miocene, but may represent a later period." No horses are certainly known in the San Pablo. Type collected by Mr. Lawler.

Type.— Univ. Cal. Pal. Coll. 21382. A third upper molar, m^3, of the left side. Measurements: (Merriam, 1915) m^3 a.p. .0267, tr. .0206; a.p. of protocone .0187, height of worn crown .0555.

Type figure.— Text Fig. 150 of this Memoir.

Characters.— (1) Resembling *Hipparion affine* Leidy in its large size and in the strong lateral compression of the protocone; (2) pre- and postfossettes narrow transversely; (3) enamel showing comparatively few plications; (4) *H. gidleyi* distinguished from *H. affine* by its narrow fossettes, wider protocone, and slightly larger size.

Merriam observes that *H. affine* and *H. gidleyi* are evidently closely related and seem to represent nearly the same stage of evolution.

Hipparion platystyle Merriam 1915.

Text Fig. 151.

Neohipparion, sp., Merriam, John C. "Vertebrate Fauna of the Orindan and Siestan Beds in Middle California," *Univ. Cal. Publ. Bull. Dept. Geol.*, Vol. 7, No. 19, Sept. 24, 1913, pp. 375–376, figs. 1*a*, 1*b*, 1*c*. *Hipparion platystyle*, n. sp. "New Species of the Hipparion Group from the Pacific Coast and Great Basin Provinces of North America," *Univ. Cal. Publ. Bull. Dept. Geol.*, Vol. 9, No. 1, June 29, 1915, p. 5.

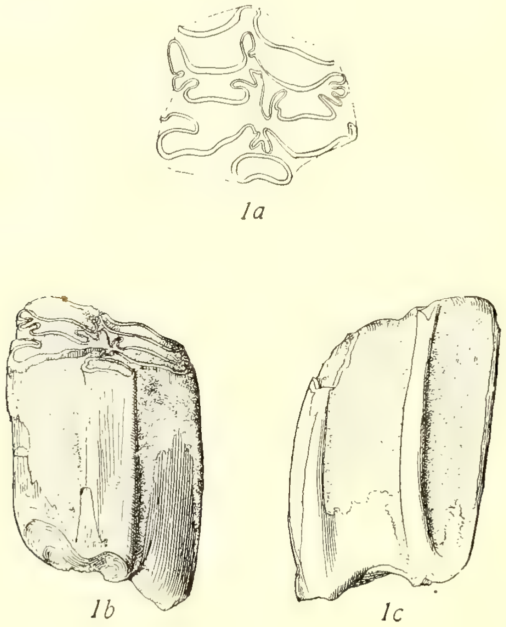


Fig. 151. Original figures of the type of *Hipparion platystyle* Merriam. Univ. Cal. Pal. Coll. 19830. Right p^2, crown, internal, external aspects. Natural size. After Merriam, 1913, figs. 1*a*, 1*b*, 1*c*, p. 375.

Horizon and locality.— (Merriam, 1913, p. 375.) "...discovered...in extensive Orindan exposures about two and one-half miles from the mouth of Tassajara Cañon, on the southwest side of Mount Diablo." California. Lower Pliocene. Type collected by Mr. Williams.

Type.— Univ. Cal. Pal. Coll. 19830. A second upper premolar, p^2, of the right side, with the walls of the crown partially fractured. Measurements: p^2 a.p. .0258, tr. .0216; protocone a.p. .0082.

Type figure.— Text Fig. 151 of this Memoir.

Characters.— (Merriam, 1915, p. 5) (1) Crown large and well cemented; (2) form of the fossettes indicates that the crown was never greatly elongated; (3) protocone pillar small, distinct from the forked pli caballin, and somewhat flattened laterally; (4) fossettes narrower transversely than in *H. mohavense;* (5) enamel walls of fossettes plicate, para- and mesostyles heavy; (6) differing from *H. mohavense* in its more flattened protocone and narrower fossettes; (7) more nearly resembling the *Hipparion* forms of the Ricardo, especially in the specimen Univ. Cal. Pal. Coll. 19478.

Hipparion gratum tehonense Merriam 1916.

Text Fig. 152.

Neohipparion gratum tehonense, n. subsp., Merriam, John C. "Mammalian Remains from the Chanac Formation of the Tejon Hills, California," *Univ. Cal. Publ. Bull. Dept. Geol.* Vol. 10, No. 8, Dec. 23, 1916, pp. 118–124, figs. 1*a*, 1*b*, 1*c*.

Horizon and locality.— Chanac formation, southern end of the San Joaquin valley, California. Of an early Pliocene or latest Miocene phase. Type collected by J. P. Buwalda.

Type.— Univ. Cal. Pal. Coll. 21780. A right superior molar, m^1?.

Type figure.— Text Fig. 152 of this Memoir.

Characters.— (Merriam, 1916, p. 118) "This species corresponds approximately in size and form to *Neohipparion gratum* of the Great Plains region. It is doubtfully distinguished from the typical form of that species by the tendency to show a more nearly circular cross-section of the protocone and by somewhat dubious characters in width of crown and nature of the enamel folds bordering the fossettes."

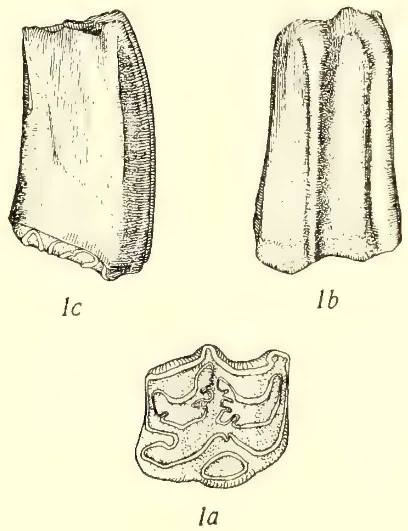


Fig. 152. Original figures of the type of *Hipparion gratum tehonense* Merriam, Univ. Cal. Pal. Coll. 21780, m^1?. (1*a*) Occlusal view; (1*b*) outer view; (1*c*) posterior view. Natural size. After Merriam, 1916, p. 119.

"The character of the protocone of the Chanac form (figs. 1*a* to 1*c*) suggests *Hipparion plicatile* of the Alachua clays of Florida, but the crowns in that species seem larger and relatively wider than in the Chanac species. *H. ingenuum* also of the Alachua clays is not widely removed from the Chanac species, but the protocone is smaller. The Chanac species differs from *Neohipparion montezumæ* in its more nearly circular section of protocone and possibly in a tendency to relatively greater transverse diameter of the fossettes."

"The characters of the Chanac species represented by specimen 21780 [the type] are in general like those of *Hipparion mohavense* of the Ricardo Pliocene, but they are shown in a form with smaller dimensions, and approaching the combination of characters of *N. gratum*. The species is evidently very near the Great Plains form of *N. gratum*, and it is not impossible that larger collections will exhibit a range of characters making even subspecific separation inadvisable."

Regarded by Merriam (1916, p. 118) as very near to *Hipparion gratum* Leidy.

Hipparion anthonyi Merriam 1916.

Text Fig. 153.

Hipparion anthonyi n. sp., Merriam, John C. "Mammalian Remains from a Late Tertiary Formation at Ironside, Oregon," *Univ. Cal. Publ. Bull. Dept. Geol.* Vol. 10, No. 9, Dec. 1916, pp. 131–133, figs. 1a, 1b, 1c.

Horizon and locality.— (Merriam, pp. 130–131) "....from Tertiary beds exposed three-fourths of a mile south of Ironside, Malheur County, Oregon....The horizon at which this specimen was found is presumed to be early Pliocene, or latest Miocene....The Ironside region, in which the mammalian finds are reported, is situated on the extreme northern border of Malheur County, Oregon, and is about thirty miles west of the middle of the eastern border of the state. This region lies at the southeastern base of the Blue Mountains, and is at the northern end of the great series of broken plains and short mountain ranges extending through southeastern Oregon into Nevada. The Ironside region is drained by Willow Creek, a tributary of Malheur River....The mammal-bearing formation consists of buff sandy shales and shales with but little sand. The beds stand at varying angles ranging up to a degree of inclination of at least 20 degrees. Locality 3037, at which the most important specimens were found, is located about three-fourths of a mile southwest of Ironside Post Office."

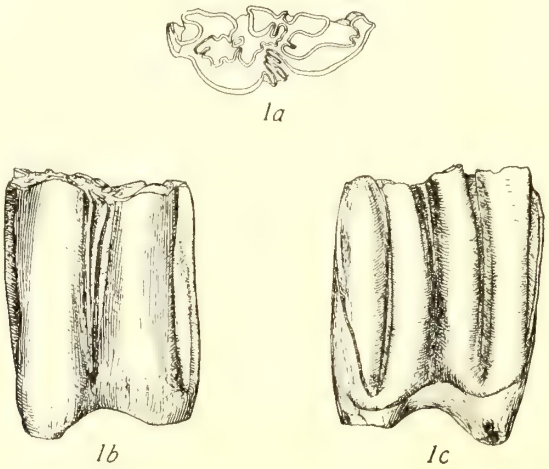


Fig. 153. Original figures of the type of *Hipparion anthonyi* Merriam, Univ. Cal. Pal. Coll. 22351, p_2 of the right side. (1*a*) Occlusal view, (1*b*) outer view, (1*c*) inner view. Natural size. After Merriam, 1916, p. 132.

Type.— (Merriam, p. 131.) "Type specimen a second lower premolar, no. 22351 [Univ. Cal. Pal. Coll.]".

Type figure.— Text Fig. 153 of this Memoir.

Characters.— (Merriam, 1916, pp. 131–132) [The type] "Crown of medium height, narrow transversely. Enamel pattern showing uncommonly strong secondary plications. Several very strong secondary plications forming a sheaf of projecting folds on anterior side of hypoconid. Specimen 22351 (Figs. 1*a* to 1*c*) [the type] differs from *Merychippus* and *Pliohippus* in its greater relative size and stage of advance of the metaconid-metastylid column and entoconid, and in greater complication of its enamel folds. Of the Great Basin and Pacific Coast province equids *Hipparion mohavense callodonte* of the Ricardo Pliocene most nearly approaches the form from Ironside. In the West Coast *Merychippus* and *Pliohippus* species the metaconid-metastylid column is relatively shorter anteroposteriorly, and wider transversely, and the entoconid is not filled out to the same extent on the antero-internal angle. In general the entoconid of *Merychippus* and *Pliohippus* species is truncated obliquely on the antero-internal angle by a plane or curved face, extending outward and forward from the inner side, while in *Hipparion* this region is expanded and the cross-section of the entoconid tends to take on a rectangular outline, instead of the approximately triangular section seen in *Merychippus*, or the triangular to imperfectly rectangular but anteroposteriorly short section seen in *Pliohippus*."

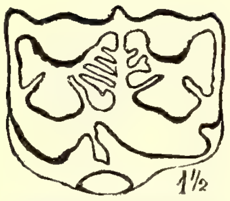
PLIAUCHENIA-PERACERAS-HIPPARION INGENUUM ZONE. 14. LOWER PLIOCENE.

This zone represents the second phase of the Lower Pliocene.

Hipparion ingenuum Leidy 1885.

Text Fig. 154.

Hippotherium ingenuum, Leidy, Joseph. "Rhinoceros and Hippotherium from Florida," *Proc. Acad. Nat. Sci. Phila.* Vol. XXXVII, 1885 (sig. dated Apr. 7, 1885), p. 33, text fig. p. 33.



Hippotherium ingenuum.

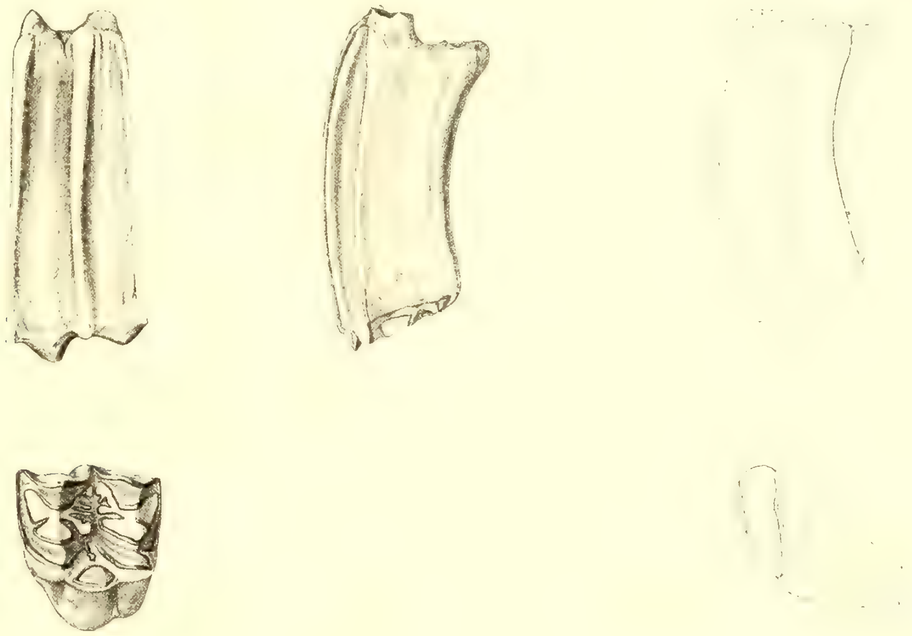


Fig. 154. (Left) *Hipparion ingenuum* Leidy, U. S. Nat. Mus. 3306, original figure of one of the two type molars, m^2 of the left side. One and one-half natural size. After Leidy, 1885, p. 33. (Right) Type specimens, drawn under the direction of Osborn by B. Yoshihara. (Centre figures) Crown, external, and anterior views of type molar, U. S. Nat. Mus. 3306. Osborn figures natural size. Note: original figure is viewed in line of the axis of the tooth, the new figure is viewed at right angles to the grinding surface; hence the difference in proportions.

Horizon and locality.— (Leidy) The Alachua clays, or Archer beds of Archer, Florida. Upper Miocene or Lower Pliocene (fauna of same age as that of the Republican River formation of western Kansas). Type collected by J. C. Neal.

Type.— U. S. Nat. Mus. 3306. (Leidy) Two superior molar teeth of the left side. Measurements: (Gidley, 1907) m^2 a.p. .0185, tr. .0165, height of crown .043 outside, .034 inside.

Type figure. Text Fig. 154 of this Memoir.

Characters.— (Leidy, 1885, Gidley, 1907) (1) An animal little more than half the size of the domestic horse, *E. caballus.* (2) Foldings of the metaloph within the pre- and postfossettes, four anterior, three posterior; (3) single anterior and posterior folds in pre- and postfossette respectively; (4) prominent crochet fold and pli caballin; (5) internal islet [protocone] elliptical instead of circular. (Gidley) (6) An animal little larger than the type of *H. venustum* Leidy; (7) differing from *H. venustum* only in the characters pointed out by Leidy, which are slight and of little value. (8) Widely separated in size, in the form of the protocone, and in the enamel plications from *H. montezuma.*

Hipparion plicatile Leidy 1887.

Text Figs. 155, 155a.

Hippotherium plicatile. Leidy, Joseph. "Fossil Bones from Florida," *Proc. Acad. Nat. Sci. Phila.* Vol. XXXIX, 1887 (sig. dated Dec. 13, 1887), pp. 309–310, text fig. p. 310.

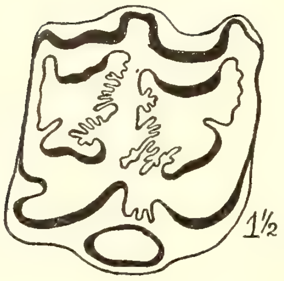


Fig. 155. Original figure of the type of *Hipparion plicatile* Leidy, U. S. Nat. Mus. 3292, an upper molar of the right side. One and one-half natural size. After Leidy, 1887, p. 310.

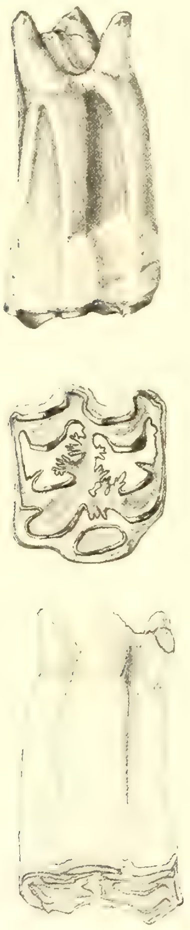


Fig. 155*a*. Three views of the type of *Hipparion plicatile* Leidy, U. S. Nat. Mus. 3292, drawn under the direction of Osborn by B. Yoshihara. Natural size.

Horizon and locality.— (Leidy.) " . . . from Mixson's bone-bed, 10 miles east of Archer, Levy County, Florida." Alachua clays or "Archer beds," Upper Miocene or Lower Pliocene. Type collected by L. C. Johnson.

Type.— U. S. Nat. Mus. 3292. (Leidy, Gidley.) An upper molar of the right side. Measurements: (Leidy) diameters of upper molar a.p. .020, tr. .023, height of crown (much worn) .030.

Type figure.— Text Fig. 155 of this Memoir.

Characters.— (Leidy, 1887) (1) Size approximating that of *Equus asinus,* exceeding that of *H. ingenuum.* (2) Triturating surface of metaloph exhibiting a complexly folded condition of the enamel quite different from that of *H. ingenuum.* (Gidley, 1907) (3) Type apparently a true molar with the crown at least half worn away by use, hence the elaborate plications [of the metaloph and crochet region] are a distinctive feature; (4) double plicrochet and triple pli caballin folds; (5) single anterior and posterior folds into pre- and postfossettes respectively; (6) protocone oval like that of *H. venustum* and *H. ingenuum.* (7) Clearly distinguished from *H. ingenuum* by its much greater size and by the difference in the character of the enamel foldings.

Gidley observes that *H. venustum, H. ingenuum* and *H. plicatile,* all from the Atlantic coast and from deposits apparently of Pliocene age, differ in some important respects from the western American species, representing in general a slightly more recent phase of development, especially in the greater length of the tooth crowns, stronger development of the external stiles, and the much more elaborate plications of the enamel borders of the fossettes. On the other hand, the retention of the primitive suboval form of the protocone, nearly circular in cross section, as in some species of *Merychippus,* relates these Atlantic coast species closely to the *Hipparion gracile* type of Europe. In foot structure, from the fragments available, it would appear that it may more nearly resemble the American Miocene forms. It seems not improbable that these animals belong to an American branch of the *Hipparion* group of the Old World.

Hipparion minor Sellards 1916.

Text Fig. 156.

Hipparion minor, sp. nov., Sellards, E. H. "Fossil Vertebrates from Florida: A New Miocene Fauna; New Pliocene Species; The Pleistocene Fauna," *Eighth Ann. Rept. Florida State Geol. Surv.* 1916, pp. 96–98, Pl. 11, fig. 10, Pl. 13, fig. 8.

Horizon and locality.— (Sellards, p. 96) "A new hipparion from Florida is of interest because of its miniature size. The species is represented by teeth obtained both from the hard rock and from the land pebble phosphate deposits." This "Bone Valley formation of Brewster, Fla." is believed to be contemporaneous with the Alachua Clays (Sellards, letter Sept. 24, 1917). Name of collector not given.

Type.— (Sellards, pp. 96–97.) "As type of this species the writer selects specimen No. 5867 of the Florida Geological Survey collection from the pit of the Amalgamated Phosphate Company at Brewster. In addition two smaller teeth, from the hard rock phosphate deposit, Nos. 1167 and 1246, are referred to this species."... Measurements: Sellards, p. 97) "The anteroposterior measurement of the type specimen is 13—$\frac{1}{2}$ mm.; the greatest transverse measurement is 13 mm. The anteroposterior measurement of specimen 1167 [referred], which may be a milk tooth is 11 mm., while the transverse measurement is 11 mm."

Type figure.— Text Fig. 156 of this Memoir.

Characters.— (Sellards, pp. 97–98) "The enamel bordering the lakes in this small species is very much complicated. The inner column of the tooth is elipsoidal in the cross section. The species may be known as *Hipparion minor* ....Of the hipparions, four species have now been described from Florida. Of these the largest is *Hipparion princeps,* the type and only known specimen of which was found on Peace Creek and hence is of uncertain geologic age. The two species, *Hipparion plicatile* and *Hipparion ingenuum,* were described by Leidy from the Alachua clays, but are present also in the hard rock phosphate deposits and in the bone valley formation. Of the four species, *H. princeps* is by far the largest, while the one here described as *H. minor* is much the smallest. The presence of the three species of hipparions in the Dunnellon and Bone Valley formations is one of the strong arguments for the essential contemporaneity of these two formations."

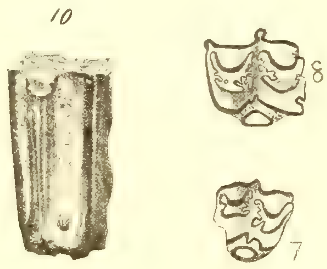


Fig. 156. *Hipparion minor* Sellards, Fla. State Geol. Surv. Coll., type, 5867, and paratype, 1167. After Sellards, 1916: Pl. 11, fig. 10, Pl. 13, fig. 8, side and crown views of the type; Pl. 13, fig. 7 crown view of the paratype. Natural size.

Hipparion mohavense Merriam 1913.

Text Fig. 157.

Hipparion (?) *mohavense,* n. sp., Merriam, J. C. "New Protohippine Horses from Tertiary Beds on the Western Border of the Mohave Desert," *Univ. Cal. Publ. Bull. Dept. Geol.* Vol. 7, No. 23, Dec. 22, 1913, p. 436, figs. 1a–3b.

Horizon and locality.— (Merriam, p. 436) "From the Ricardo Beds, in the El Paso Range, north of Mohave, California." Lower Pliocene. Type collected by C. L. Baker.

Type.— Univ. Cal. Pal. Coll. 19787. (Merriam, 1913, p. 436.) "...an upper premolar three with two associated upper cheek-teeth, and several lower teeth presumably from the same individual." Measurements: (Merriam)

	P^3	M^1	M^2
Anteroposterior diameter	.022	.0214	.0216
Transverse diameter	.023	.022	.020
Height of crown	.032+	.032+	.037

Type figure.— Text Fig. 157 of this Memoir.

Characters.— (Merriam, p. 436) (1) Crowns of upper molars nearly straight or but slightly curved, crowns not very elongate, length about one and one-half times the transverse diameter, in less worn specimens crowns may equal about twice the transverse diameter; (2) cement layer well developed on the outer and inner sides; (3) parastyle and mesostyle prominent, mesostyle especially strong on premolars, broadening toward the base; (4) outer sides of paracone and metacone may show a slight tendency to formation of a median rib, protocone, free almost to base, nearly circular in cross section or slightly elongate anteroposteriorly; (5) anterior and posterior borders of pre- and postfossettes with numerous plications; (6) a pli caballin; (7) six or more short folds on either side of the metaloph, numerous folds also from the protoloph. (8) In dimensions and general form resembling *H. richthofeni* of China and *H. gracile* of Europe, lower cheek teeth also resembling those of *H. richthofeni.*

Hipparion mohavense callodonte Merriam 1915.

Text Fig. 158.

Hipparion mohavense callodonte n. var., Merriam, John C. "New Horses from the Miocene and Pliocene of California," *Univ. Cal. Publ. Bull. Dept. Geol.*, Vol. 9, No. 4, Nov. 22, 1915, pp. 54–55, figs. 5–7.

Horizon and locality.— Ricardo Pliocene, near Ricardo postoffice on the western border of the Mohave Desert, California. Type collected by Emerson M. Butterworth.

Type.— Univ. Cal. Pal. Coll. 21311. (Merriam) "A finely preserved dentition including the upper and lower cheek-teeth with several of the incisors."

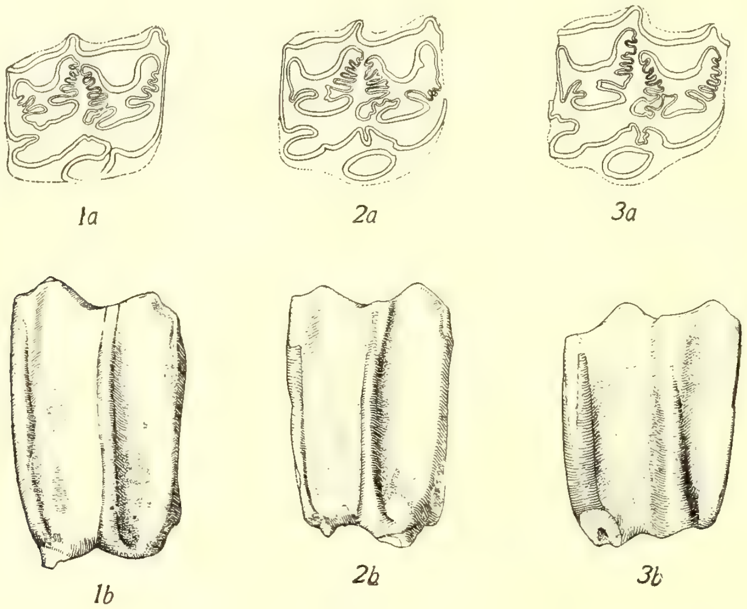


Fig. 157. Original figures of the type molars of *Hipparion* (?) *mohavense* Merriam, Univ. Cal. Pal. Coll. 19787. Figs. 1*a*, 1*b*, occlusal and outer views of m^2; figs. 2*a*, 2*b*, occlusal and outer views of m^1; figs. 3*a*, 3*b*, occlusal and outer views of p^3. Natural size. After Merriam 1913, p. 437.

Measurements of No. 21311.

P^2, anteroposterior diameter	29.9 mm.	P_2, anteroposterior diameter	28.4 mm.
P^2, transverse diameter	20.2	P_2, greatest transverse diameter	12.
P^3, anteroposterior diameter	27.4	P_3, anteroposterior diameter	27.
P^3, transverse diameter	23.2	P_3, greatest transverse diameter	13.7
P^4, anteroposterior diameter	24.8	P_4, anteroposterior diameter	27.4
P^4, transverse diameter	21.5	P_4, greatest transverse diameter	13.
P^4, height of mesostyle	45.5	P_4, height of protoconid	51.
M^1, anteroposterior diameter	24.5	M_1, anteroposterior diameter	25.8
M^1, transverse diameter	22.6	M_1, greatest transverse diameter	11.4
M^2, anteroposterior diameter	24.	M_2, anteroposterior diameter	27.3
M^2, transverse diameter	20.4	M_2, greatest transverse diameter	10.8
M^2, height of mesostyle	41.	M_2, height of protoconid	44.4
M^3, anteroposterior diameter	21.	M_3, anteroposterior diameter	25.
M^3, transverse diameter	18.	M_3, greatest transverse diameter	10.4

Type figure.— Text Fig. 158 of this Memoir.

Characters.— (Merriam, 1915, pp. 54–55) "In this form the dentition differs noticeably from that of the typical *Hipparion mohavense* of the Ricardo Pliocene. The protocone is more strongly flattened transversely, while the enamel pattern of the teeth in general shows fewer deep, smoothly-rounded folds. The plications of the enamel in this form tend to be more distinctly angular, and there are more numerous minute folds. The dimensions differ somewhat from those of the typical *H. mohavense*. The differences in dimensions and in pattern of the cheek-teeth separating this variety from typical *H. mohavense* may be due in some part to variation in stage of wear, but the characters seem sufficiently marked to require at least tentative recognition in the classification. It is possible that fuller collections may ultimately show an intergradation between this form and *H. mohavense*."

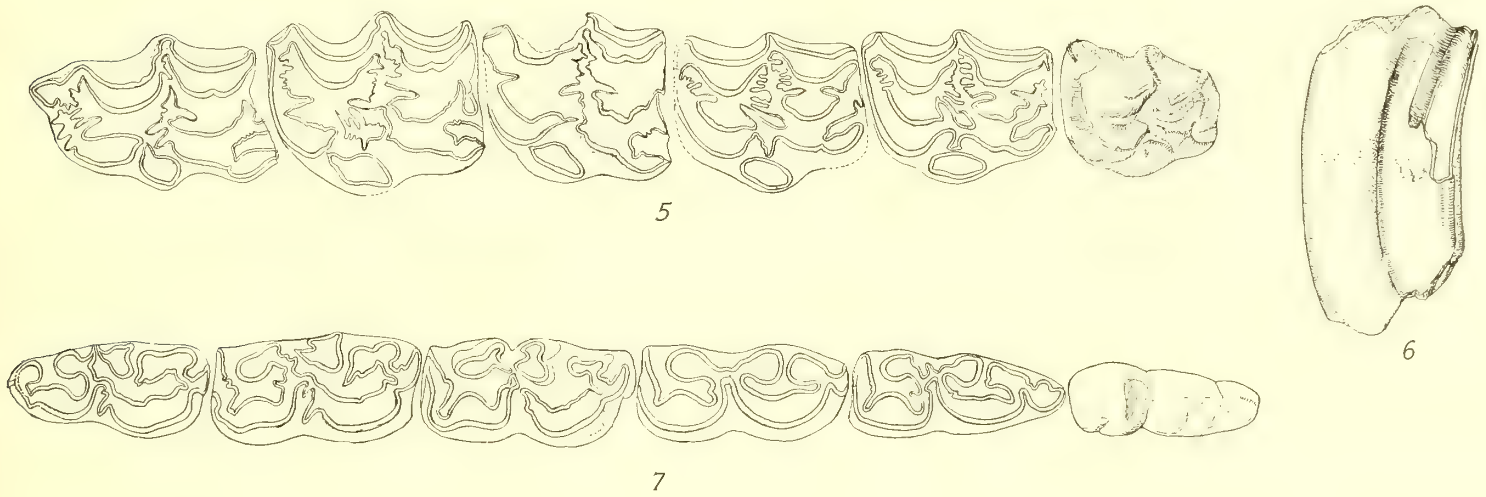


Fig. 158. *Hipparion mohavense callodonte* Merriam, Univ. Cal. Pal. Coll. 21311, original figures of upper and lower grinding teeth of the type. Natural size. After Merriam, 1915, figs. 5–7, p. 53.

PLIAUCHENIA-PLIOHIPPUS SPECTANS ZONE. 15. EARLY MIDDLE PLIOCENE.

This zone is typified in the Rattlesnake formation of Oregon.

Hipparion sinclairi Wortman 1882.

Text Fig. 159.

Hippotherium sinclairi, Wortman, Jacob L. "On the Origin and Development of the Existing Horses," *Kansas City Rev. Sci. and Industry*, Vol. VI, No. 2, June, 1882, p. 73, no figure. *Hippotherium sinclairii*, Wortman, Cope, Edw. D. "A Review of the North American Species of Hippotherium." *Proc. Amer. Philos. Soc.* Vol. XXVI, 1889 (sig. dated June 1, 1889), pp. 434–435, figs. 2, 2a.

Horizon and locality.— Cottonwood Creek, Oregon, Rattlesnake formation, Upper Miocene. Type collected by J. L. Wortman.

Type.— (Wortman) Amer. Mus. Cope Coll. 8178, upper premolar of the left side. Measurements: (Gidley, 1907) diameters of crown a.p. .020, tr. .0195, length of crown .042.

Type figure.— Text Fig. 159 of this Memoir.

Characters.— (Wortman, 1882, p. 73, Cope, 1889, p. 435, Gidley, 1907) (Wortman) "*H. sinclairi.*— Antero-internal lobe slightly concave on its inner border, and elongated fore and aft; much larger than posterior internal lobe." (Cope) (1) Readily distinguishable from the corresponding tooth of *H. occidentale* by its inferior size and relatively smaller transverse diameters; dimensions about those of *Hippodon speciosus* Leidy, differing from that species in the larger and flatter inner column [protocone], long-crowned, and less complex folds of the borders of the lakes; (2) crown long and nearly straight as in *Hipparion occidentale;* (3) in its present worn condition little external cement; (4) outlines of the lakes [fossettes] not extended inward as in *H. occidentale* and transverse diameters relatively small; (5) anterior lake [prefossette] with one posterior inflection, one interior and one anterior inferior; (6) posterior lakes [postfossette] two anterior inflections, one interior and one posterior, a short loop extends toward the inner column area; (7) the latter [protocone] convex on the outer side and without trace of angle or apex. (8) (Gidley) The type upper molar presents the characters of the genus *Neohipparion;* (9) somewhat larger than the type of *H. montezuma* Leidy; (10) differs from that species in the relatively larger and differently formed protocone and the more simple enamel plications; (11) inner face of protocone of *H. sinclairi* slightly concave as in *H. affine.*

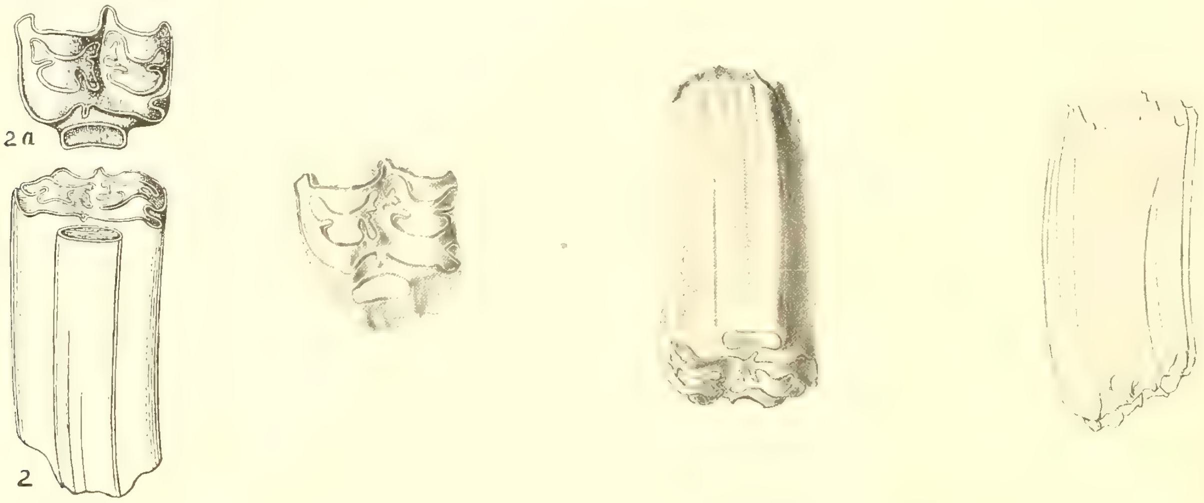


Fig. 159. Type of *Hipparion sinclairi* Wortman, Amer. Mus. 8178. (Left) Original figure of the type, after Cope, 1889, figs. 2, 2*a*, p. 458. (Three right-hand figures) Drawings of type under the direction of Osborn by S. Oka; crown, interior, and anterior views. Crown in original figure is drawn at an oblique angle to the grinding surface. All figures natural size.

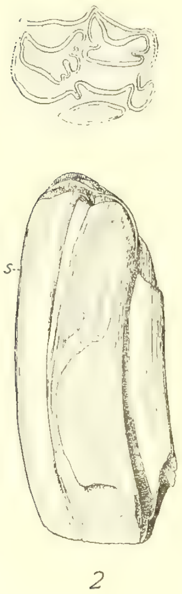


Fig. 160. Original figure of the type of *Hipparion molle* Merriam, Univ. Cal. Pal. Coll. 21370, third superior molar of the left side. Inner view and cross section at the point indicated by *S*. Natural size. After Merriam, 1915, fig. 2, p. 2.

Hipparion molle Merriam 1915.

Text Fig. 160.

Neohipparion molle, n. sp., Merriam, John C. "New Species of the Hipparion Group from the Pacific Coast and Great Basin Provinces of North America," *Univ. Cal. Publ. Bull. Dept. Geol.*, Vol. 9, No. 1, June 29, 1915, p. 3, fig. 2.

Horizon and locality.— From the lower Jacalitos, North Coalinga region, California. Lower Pliocene. Type collected by T. H. Ruckman.

Type.— Univ. Cal. Pal. Coll. 21370, an upper molar of the left side, m^3. Measurements: (Merriam) m^3 a.p. .0193 approx.; tr. 0158 approx.; a.p. diameter of protocone .0094, length of crown .048.

Type figure.— Text Fig. 160 of this Memoir.

Characters.— (Merriam, 1915) (1) Characterized by the length and narrowness of the upper cheek teeth; (2) simplicity of the enamel borders of the transversely narrow pre- and postfossettes; (3) unusually long anteroposterior diameter of the laterally compressed protocone. (4) Of much smaller size than the type of *H. mohavense,* fossettes relatively narrow, walls of the fossettes showing less plication. (5) Resembling the type of *H. montezuma* Leidy in general dimensions.

Merriam (1915, p. 3) observes that the type of *H. molle* shows resemblances to the type of *H. montezuma* Leidy, of Hidalgo, Mexico, also to the type of *H. sinclairi* Wortman of the Rattlesnake Pliocene of eastern Oregon.

Hipparion leptode Merriam 1915.

Text Fig. 161.

Neohipparion leptode, n. sp., Merriam, John C. "New Species of the Hipparion Group from the Pacific Coast and Great Basin Provinces of North America," *Univ. Cal. Publ. Bull. Dept. Geol.* Vol. 9, No. 1, June 29, 1915, pp. 3–4, fig. 3.

Horizon and locality.— Locality 1101, Thousand Creek formation, Thousand Creek, Nevada, Lower-Middle Pliocene. Name of collector not given.

Type.— Univ. Cal. Pal. Coll. 19414. An inferior molar, m_2. Measurements: (Merriam) a.p. .029+, tr. .011, a.p. of metaconid-metastylid column .0146, greatest length of crown .066.

Type figure.— Text Fig. 161 of this Memoir.

Characters.— (Merriam, 1915) (1) Resemblances to *Hipparion eurystyle* Cope from the Clarendon formation, Paloduro Cañon, Texas, but of larger size and differing in details of structure; (2) crown rather elongate, slender, relatively straight, well cemented, much compressed laterally; (3) metaconid-metastylid column long anteroposteriorly, narrow transversely, with wide, flat internal groove; (4) hypoconid ridge prominent; (5) a strong external protoconid ridge present.

Merriam observes that the type represents a species in many respects near *H. eurystyle* and also resembling *H. occidentale* in many characters. The Thousand Creek species is tentatively distinct. A referred upper molar (Univ. Cal. Pal. Coll. 12581) presents characters which may be correlated with the structure of the lower molar type.

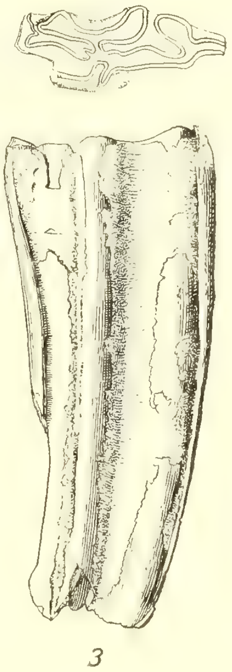


Fig. 161. Original figure of the type of *Hipparion leptode* Merriam, Univ. Cal. Pal. Coll. 19414, m_2. Natural size. After Merriam, 1915, fig. 3, p. 4.

Hipparion montezuma Leidy 1883.

Text Fig. 162.

Hippotherium montezuma, Leidy, Joseph. "On Remains of Horses," *Proc. Acad. Nat. Sci. Phila.* Vol. XXXIV, 1882 (sig. dated Jan. 16, 1883), pp. 290–291, text fig. p. 291.

Horizon and locality.— (Leidy, p. 290) "The remaining specimens are of more interest than the preceding, and consist of two bone fragments and three teeth (Nos. 1–5, 11629), which were obtained by Mr. Ellis Clarke, Jr., from near Lacualtipan, Hidalgo, Mexico. According to the accompanying letter, they were discovered in a thirty inch clay bed, lying between an upper four inch, and an under four feet stratum of coal, overlying a limestone with small shells. The fossils belong to the three-toed horse, *Hippotherium* (*Hipparion*), and are probably of pliocene age, though they may be miocene." ? Upper Miocene.

Type.— U. S. Nat. Mus. 3304. A superior premolar, p^3 or p^4 of the right side. Measurements: (Gidley, 1907) p^3 or p^4 a.p. .0195, tr. .017, height of crown, external, .047.

Type figure.— Text Fig. 162 of this Memoir.

Characters.— (Leidy, p. 291) (1) Type an animal about the size of *H. venustum* and of *H.* (*Hippodon*) *speciosus;* (2) distinguished by differences in the enamel plications; (3) protocone greatly elongated anteroposteriorly, compressed transversely; (Gidley, 1907) (4) relatively small size and comparative great length of crown; (5) in general related to the *H. whitneyi* types; (6) plications confined to the metaloph and crochet region of the protoconule, the latter double in prefossette and double opposite the protocone.

Hipparion peninsulatum Cope 1885.

Text Fig. 163.

Hippotherium peninsulatum, sp. nov., Cope, Edw. D. "Pliocene Horses of Southwestern Texas," *Amer. Naturalist*, Vol. XIX, No. 12, Dec. 1885, pp. 1208–1209, no description, Pl. xxxvii, fig. 5. "Report on the Coal Deposits near Lacualtipan, in the State of Hidalgo," *Proc. Amer. Philos. Soc.* Vol. XXIII, 1886 (sig. dated Dec. 2, 1885), p. 150, fig. 1.

Horizon and locality.— (Cope, 1885, p. 150) From the Loup Fork shales of Tehuichila, Vera Cruz, Mex. Name of collector not given.

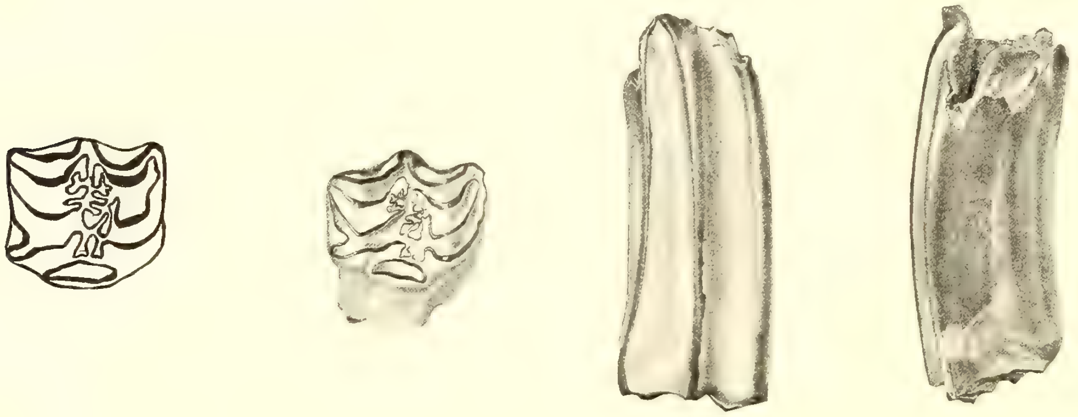


Fig. 162. *Hipparion montezuma* Leidy, U. S. Nat. Mus. 3304, right p^3 or p^4. (Left) Original figure of the type, after Leidy, 1883, p. 291. (Three right-hand figures) Type tooth redrawn under the direction of Osborn by S. Oka; crown external, and anterior views. All figures natural size.

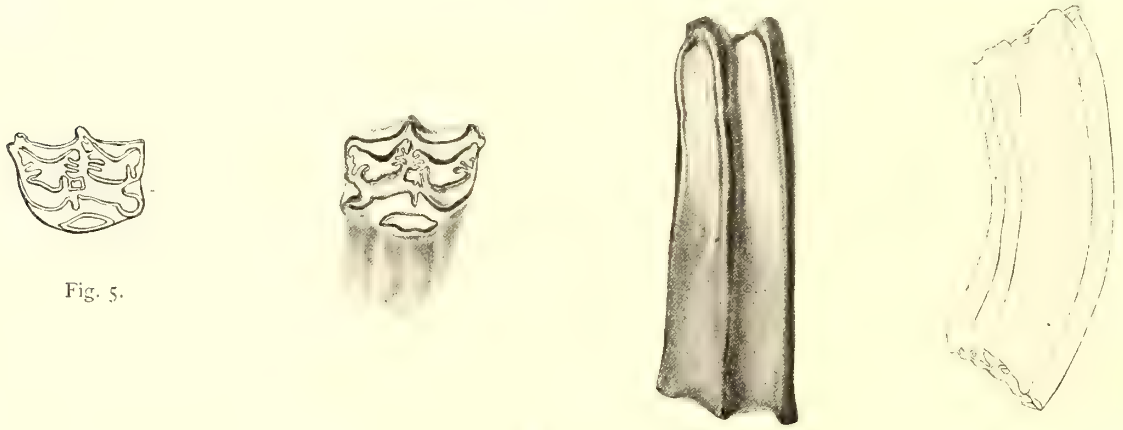


Fig. 163. Type of *Hipparion peninsulatum* Cope, Amer. Mus. Cope Coll. 8345, a right superior molar, ?m^2. (Left) Original figure of the type, after Cope, 1885, fig. 5. (Three right-hand figures) Type tooth redrawn under the direction of Osborn by S. Oka; crown, external, anterior views. Original figure is viewed in line of the axis of the tooth, the new figure at right angle to the grinding surface; hence the difference in proportion. All figures natural size.

Type.— Amer. Mus. Cope Coll. 8345. (Cope, Gidley) A right superior molar, ?m^2. Measurements: (Gidley, 1907) m^2 a.p. .0175, tr. .015, height of crown, outside .0515, inside .040.

Type figure.— Text Fig. 163 of this Memoir.

Characters.— (Cope, 1885, p. 150) (1) The type an animal of small size. (2) Crown of superior molar long, curved; (3) grinding face with anteroposterior diameter considerably exceeding transverse; (4) protocone large and narrow anteroposteriorly, oval in section, with inner and outer borders convex; (5) anterior and posterior borders of both pre- and post-fossettes doubly or triply plicate, prominent crochet and pli caballin folds; (6) prominent para- and mesostyles; (7) enamel plication resembling that of *H. venustum*, which is of similar dimensions but differs in the protocone section. (Gidley, 1907) (8) Type agrees very closely with that of *H. montezuma* Leidy; (9) the type a true molar, somewhat smaller than that of *H. montezuma*, which is a premolar, the difference in size such as might exist between molar and premolar teeth of one individual; (10) localities from which the types were obtained not widely separated.

This type is regarded by Gidley (1907) as probably identical with *H. montezuma* Leidy.

Hipparion rectidens Cope 1886.

Text Fig. 164.

Hippotherium rectidens, sp. nov., Cope, Edw. D. "On Two New Species of Three-toed Horses from the Upper Miocene, with Notes on the Fauna of the Ticholeptus Beds," *Proc. Amer. Philos. Soc.*, Vol. XXIII, 1886 (sig. dated Apr. 15, 1886), pp. 360–361, no figure. "A Review of the North American Species of Hippotherium," Vol. XXVI, 1889 (sig. dated June 1, 1889), pp. 435, 458, figs. 3, 3a.

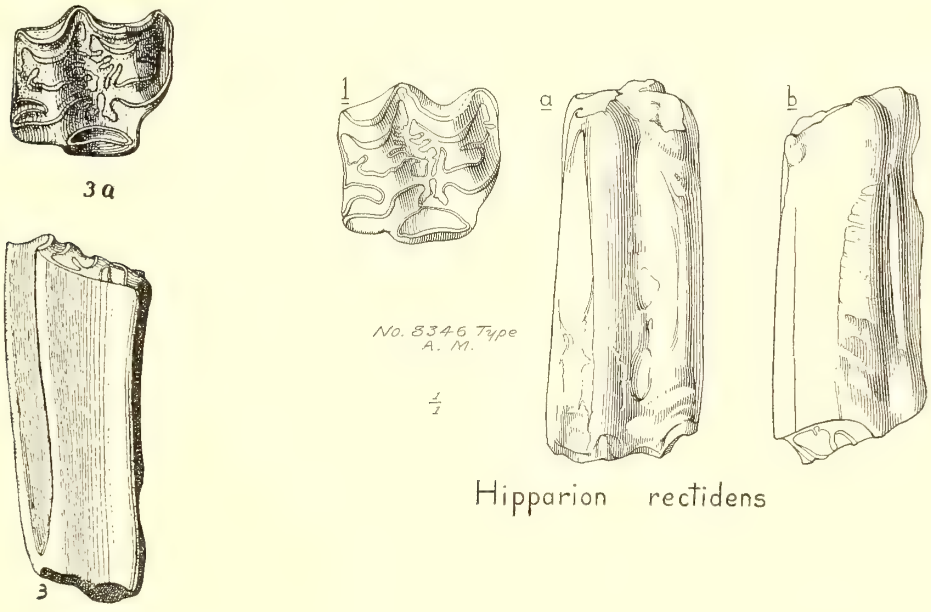


Fig. 164. Type of *Hipparion rectidens* Cope, Am. Mus. Cope Coll. 8346. (Left) Original figures of the type; 3 lateral view, 3*a* crown view. After Cope, 1889. (Three right-hand figures) Type tooth redrawn under the direction of Osborn; crown, (a) external, and (b) anterior views. All figures natural size.

Horizon and locality.— (Cope, 1886) Loup Fork, Upper Miocene formation of Tehuichila, Vera Cruz, Mexico. Type collected by Dr. Santiago Bernard. Probably Upper Miocene.

Type.— Am. Mus. 8346 (Gidley, 1907) An upper ? premolar of the right side. Measurements: (Cope, 1886) diameters of crown, a.p. .0215, tr. .0215, length of crown .045.

Type figure.— Text Fig. 164 of this Memoir.

Characters.— (Cope, 1886) (1) Enamel folds similar to those of the type of *H. peninsulatum* from the same locality; (2) including the subquadrate central loop [protocone], which is nearly cut off from the anterior lake [prefossette], tooth differing from *H. peninsulatum* in its larger size, presenting 6% more area of grinding surface; (3) shaft of tooth straight instead of being strongly curved; (4) crown owing to wear nearly square, while it is oblong in the type of *H. peninsulatum;* (5) two large loops extend inward toward the column instead of one [*i. e.* double pli caballin].

Gidley observes (1907, p. 905) that this type with its wide and compressed protocone, deeply plicate enamel borders of the fossettes, and long crown, definitely belongs to the *Neohipparion* group although its specific relations are somewhat indefinite.

The characters pointed out by Cope apparently distinguish it from any other described species.

Hipparion venustum Leidy 1859.

Text Fig. 165.

Hippotherium venustum, Leidy, Joseph. "Description of Vertebrate Fossils," in "Post-Pliocene Fossils of South-Carolina," by Francis S. Holmes, Nos. 8, 9, 10, 1859, p. 105, Pl. xvi, figs. 32–33a. *Hipparion venustum*, [Communicated without title], *Proc. Acad. Nat. Sci. Phila.*, Vol. VI, No. VII, 1853, p. 241, no figure, no description.

Horizon and locality.— (Leidy, 1853, p. 241.) "2. Two superior molar teeth of a species of *Hipparion*, discovered by Prof. Holmes, on Ashley River, South Carolina. It is the first time this genus has been found in America. For the species the name *H. venustum* was proposed." (1859) Discovered by Prof. Holmes and Capt. Bowman in the Post-Pliocene beds of the Ashley river. (Osborn, 1910, pp. 471–472[1]) The principal locality is at Ashley, in a bluff about thirty feet high, having at its base a Pliocene limestone composed of marine shells while the Post-Pliocene layer is a shallow river formation consisting of yellow sands with bands of ferruginous clay four feet in thickness. The Ashley River fauna is chiefly mid-Pleistocene. The type of *H. venustum* may have been washed in by the erosion of Pliocene sands and mingled with true Pleistocene remains.

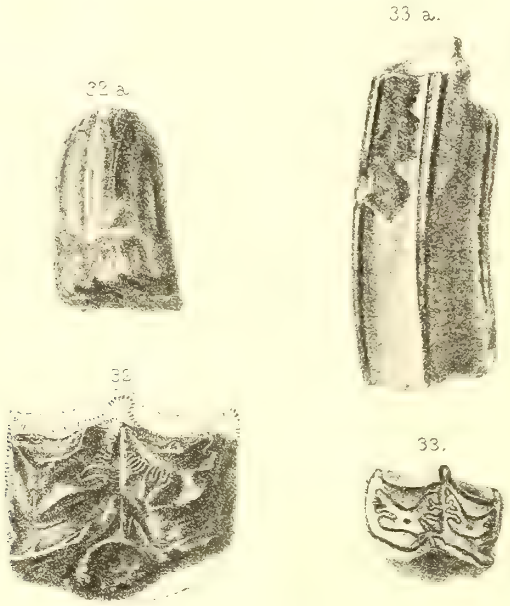


Fig. 165. *Hipparion venustum* Leidy. 33, 33a Crown and external views of type, natural size; 32 crown view of paratype, twice natural size; 32a internal view of paratype, natural size. After Leidy, 1859, Pl. xvi.

Type and paratype.— (Leidy, 1859, p. 105) Type misplaced. (Type) "The larger specimen, pl. XVI, figs. 33, 33a". A left upper molar with the protocone broken away; (paratype) a right upper molar with the ectoloph broken away (Figs. 32, 32a). Measurements: (Gidley, 1907, taken from Leidy's figures) type, a.p. .018, tr. .016; paratype, a.p. .0155, tr. .013.

Type figure.— Text Fig. 165 of this Memoir.

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[1] Osborn, H. F. "The Age of Mammals in Europe, Asia and North America." 8vo. The Macmillan Co., Oct. 1910, 635 pp., 220 text figs.

Characters.— (Leidy, 1859, p. 105) (1) Crown of the larger specimen, (type, fig. 33) with enamel stained jet black and dentine and cement gray; (2) broken at the bottom and without inner median enamel column [protocone]; (3) in its present condition two inches in length; (4) moderate degree of internal and posterior curvature. The smaller (paratype, fig. 32) brown in color; (5) half worn down; (6) a little less than an inch in length; (7) inner median enamel column [protocone] anteroposteriorly reniform. (Gidley, 1907) (8) One of the smallest and apparently most highly specialized species of the group. (9) Greater elongation of the tooth crowns; (10) very complex plications of the walls of the fossettes; (11) a small, well rounded protocone, differing from that of *Hipparion whitneyi* and resembling that of *H. gracile* of Europe.

ELEPHAS IMPERATOR-EQUUS EXCELSUS ZONE. 19. LATEST PLIOCENE OR EARLIEST PLEISTOCENE.

Equus princeps Leidy 1890.

Text Fig. 166, 166a.

Hippotherium princeps, Leidy, Joseph. "Hippotherium and Rhinoceros from Florida," *Proc. Acad. Nat. Sci. Phila.* Vol. XLII, 1890 (sig. dated July 29, 1890), pp. 182–183, text fig. p. 182.

Hipparion princeps Leidy 1890, = *Equus ?fraternus* Leidy, *auct.* Gidley, 1918.

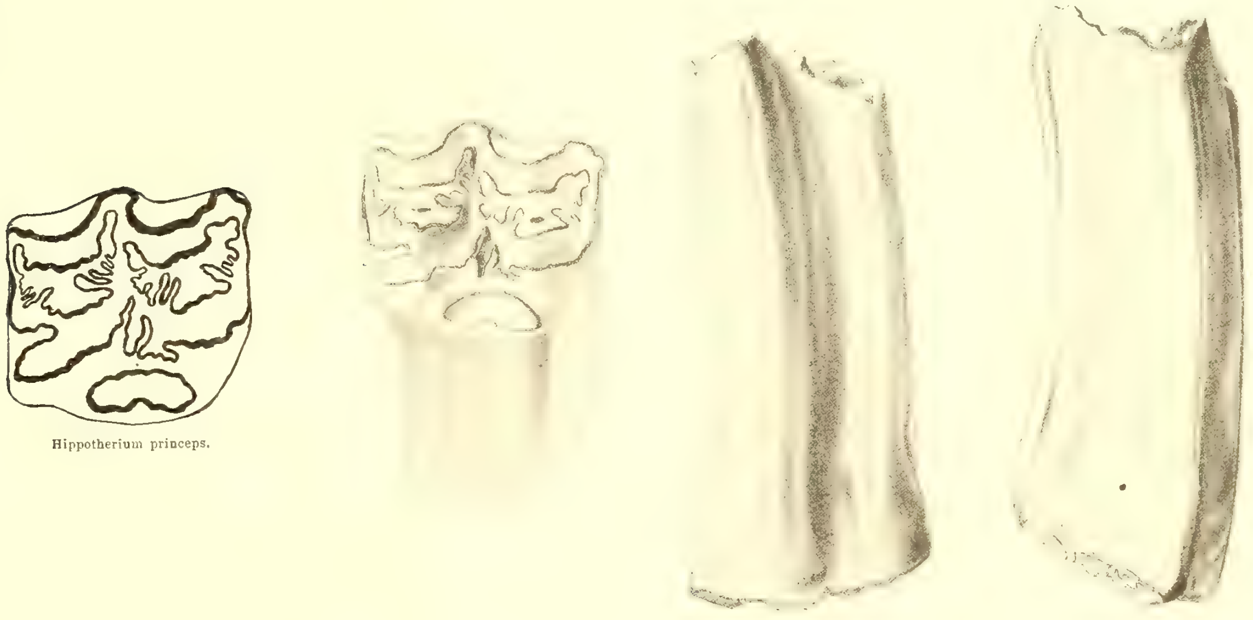


Fig. 166. Type of *Hipparion princeps* Leidy (= *Equus ? fraternus* Leidy), U. S. Nat. Mus. 3299. (Left) Original figure of the type, after Leidy, 1890, p. 182. (Three right-hand figures) Type tooth redrawn under the direction of Osborn by S. Oka; crown, external and anterior views. Natural size.

Horizon and locality.— (Leidy) Peace Creek, De Soto County, Florida, Peace Creek formation of late Pliocene or early Pleistocene age. Type collected by Joseph Willcox and Wm. M. Meigs, from the phosphate bed of T. S. Morehead. These phosphate beds contain also *Equus*, *Elephas*, and *Glyptotherium*.

Type.— U. S. Nat. Mus. 3299. (Leidy, Gidley) A premolar, p^3 or p^4, of the right side. Measurements: (Leidy)

	H. ingenuum	*H. plicatile*	*H. princeps*
Fore and aft diameter	.019	.020	.032
Transverse	.017	.024	.031
Height of crown	.043+	.030+	.075+

Type figure.— Text Fig. 166 of this Memoir.

Characters.— (Leidy) (1) Type an animal one-third larger than *Hipparion gracile,* or the Floridian *H. plicatile,* equalling in size *Equus caballus;* (2) the tooth, a second or third upper "molar," is three inches long in its outer curvature, and the worn triturating surface, represented in the accompanying wood cut, measures fifteen lines fore and aft and fourteen lines transversely; (3) the arrangement of the enamel most nearly approximates the condition observed in *H. occidentale* from our western Tertiary formation; (4) the inner column, [protocone] of uniform breadth the entire length of the crown, measures half an inch fore and aft and in section is horizontally reniform, *i. e.* the protocone is elongate anteroposteriorly, convex externally, slightly concave internally. (Osborn, 1918) (5) Deep enamel plications on both anterior and posterior borders of the pre- and postfossettes, double crochet fold in prefossette, and double pli caballin folds opposite protocone.

Gidley (1907) related this species to his "*Neohipparion*" group with broad, flattened protocones, and regarded it as a very large and highly specialized animal, perhaps one of the last of the "*Neohipparion*" group which may have survived into the Pleistocene, being contemporary with some of the earlier species or *Equus,* with remains of which the type tooth was found associated.

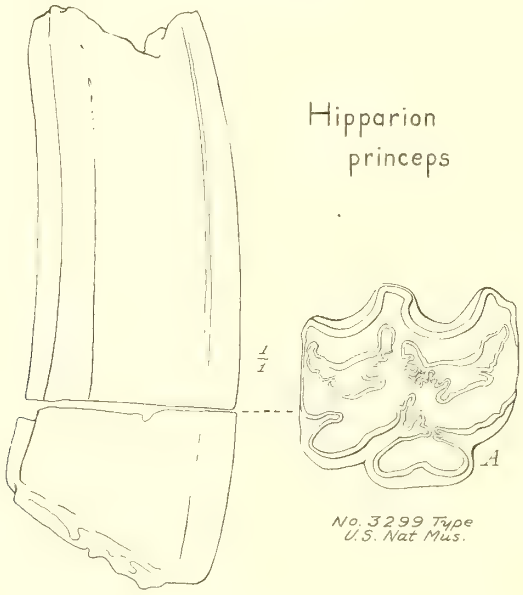


Fig. 166a. Type of *Hipparion princeps* Leidy, U. S. National Mus. 3299, as sectioned by J. W. Gidley, to demonstrate its relationship to if not identity with the paratype of *Equus fraternus* Leidy.

Gidley (1918) recently had the *H. princeps* type sectioned less than a-half inch above its triturating surface, and found that somewhere below this plane the protocone joins the protoconule; and that therefore the only *Hipparion* character of this type disappears. The type of *H. princeps* cannot now be distinguished from corresponding teeth of *Equus fraternus* Leidy, as that species has been redefined by Hay; it agrees in size, proportions, enamel plication, and general appearance (Gidley, letter to author, Jan. 30, 1918).

GENUS **HYPOHIPPUS** LEIDY 1858.

Proc. Acad. Nat. Sci. Phila. 1858, p. 26.

Synonym.— *Drymohippus* Merriam, subgenus *H.* (*Drymohippus*) *nevadensis*, 1913.

Genotype.— *Hypohippus* (*Anchitherium*) *affinis* Leidy, from the Niobrara River, near Fort Niobrara, Nebraska, Lower Pliocene, Nebraska formation, Procamelus-Hipparion zone.

This genus, which was originally based on a single superior deciduous premolar, has become securely established since 1858 through the discovery of a series of important specific stages, namely, *Hypohippus equinus* Scott from the Middle Miocene, Ticholeptus-Merychippus zone, of the upper sections of the Deep River formation of Montana, *H. osborni* Gidley of the typical Middle Miocene of Pawnee Creek, Colorado, *H. nevadensis* Merriam from Stewart Valley, Nevada, probably Upper Miocene, and finally *H. matthewi* Barbour from the Lower Pliocene of Devil's Gulch, Nebraska.

These horses are believed to have been persistently browsing and forest-living, with habits somewhat like those of the tapirs and the primitive species of browsing rhinoceroses. Unlike all other late Tertiary equines the feet are isotridactyl, the lateral digits continuing to rest on the ground and functioning. As browsers hypsodontism is slowly acquired although it is incipient in the Lower Pliocene *Hypohippus matthewi*, which is subhypsodont. In the grinders none of the secondary folds appear, such as the crochet, and the hypostyle remains small and primitive, not passing beyond the stage observed in *Mesohippus*.

The characters common to the six species known, including the *Hypohippus zitteli* of the Pliocene of China, are the following:

1. Protoloph and metaloph distinct and continuous, cones and conules lophoid, proto- and metaconules not expanded.
2. Hypostyle a looped or rounded cingule, not free from the postcingulum; internal and external cingula vestigial or atrophied except in *H. matthewi*, which has strong internal cingulum.
3. Posterior grinding teeth, m$\frac{3}{3}$, reduced.
4. Inferior molars with external cingulum.
5. Skull relatively small, microcephalic.
6. Preorbital or facial region relatively short.
7. Lachrymal fossa deep, narrow, and superior in position (*H. osborni*).
8. No malar fossa (*H. osborni*).
9. Nasals expanded anteriorly.
10. Limbs relatively short, feet isotridactyl.
11. Mts. III articulates laterally with both cuboid and mesocuneiform.

TICHOLEPTUS-MERYCHIPPUS ZONE. MIDDLE MIOCENE.

Hypohippus equinus Scott 1893.

Text Fig. 167.

Anchitherium equinum sp. nov., Scott, W. B. "The Mammals of the Deep River Beds," *Amer. Naturalist*, Vol. XXVII, No. 319, July, 1893, p. 661, no figure. "The Mammalia of the Deep River Beds," *Trans. Amer. Philos. Soc.* N. S. Vol. XVIII, 1894, p. 94, Pl. iii, figs. 25–28.

Horizon and locality.— Upper beds of Deep River (Lower Loup Fork), Mont. Middle Miocene, Deep River Formation, Deep River Valley, Mont. Type collected by I. Benet.

Type.— Princeton Mus. 10404 (Scott, *Trans.* 1894, p. 95) "The type specimen of the species consists of a fragmentary skull (with the dentition almost complete), several vertebræ from different regions, the fore limb (lacking the

I. TYPE DESCRIPTIONS OF THE SPECIES OF HYPOHIPPUS AND ARCHÆOHIPPUS IN CHRONOLOGIC ORDER.

Date	Original name and author	Present reference	Locality	Life zone
1858	*Anchitherium (Hypohippus) affinis* Leidy	*Hypohippus affinis*	Ft. Niobrara, Nebr.	?Procamelus-Hipparion zone
1886	" *ultimum* Cope	*Archæohippus ultimus*	Cottonwood Creek, Ore.	Ticholeptus-Merychippus zone
1894	" *equinum* Scott	*Hypohippus equinus*	Deep River Valley, Mont.	" " "
1907	*Hypohippus osborni* Gidley	" *osborni*	Pawnee Buttes, northeastern Col.	" " "
1913.1	" *(Drymohippus) nevadensis* Merriam	" *nevadensis*	Mina, Stewart Valley, Nev.	?Procamelus-Hipparion zone
1913.2	*Archæohippus mourningi* Merriam	*Archæohippus mourningi*	Mohave Desert, Cal.	" " "
1914	*Hypohippus matthewi* Barbour	*Hypohippus matthewi*	Devil's Gulch, Nebr.	" " "

II. TYPES AS RECORDED OR INFERRED IN 1917 IN GEOLOGIC SUCCESSION.

Date	Species, Present reference	Life zone	Formation, Beds	Locality	Age
1913	*Archæohippus mourningi* Merriam	?Procamelus-Hipparion zone	Barstow formation	Mohave Desert, Cal.	Upper Miocene
1914	*Hypohippus matthewi* Barbour	" " "	Devil's Gulch	Devil's Gulch, Nebr.	" " or Lower Pliocene
1913	" *nevadensis* Merriam	" " "	Stewart Valley formation	Mina, Stewart Valley, Nev.	" " " " "
1858	" *affinis* Leidy	" " "	Niobrara River "	Fort Niobrara, Nebr.	" " " " "
1907	" *osborni* Gidley	Ticholeptus-Merychippus zone	Pawnee Creek "	Pawnee Buttes, northeastern Col.	Middle Miocene
1894	" *equinus* Scott	" " "	Deep River "	Deep River Valley, Mont.	" "
1886	*Archæohippus ultimus* Cope	" " "	Mascall "	Cottonwood Creek, Oregon	" "

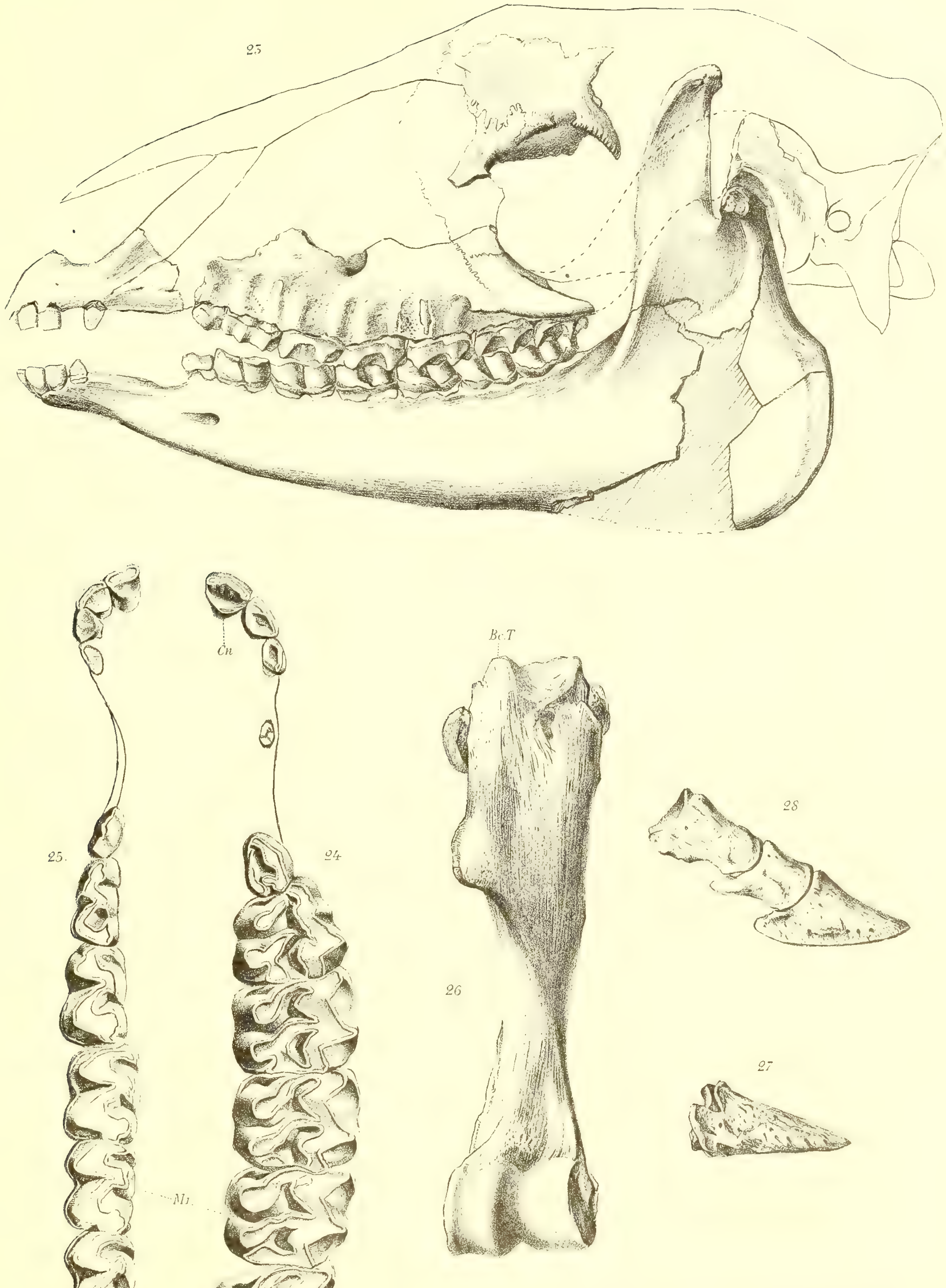
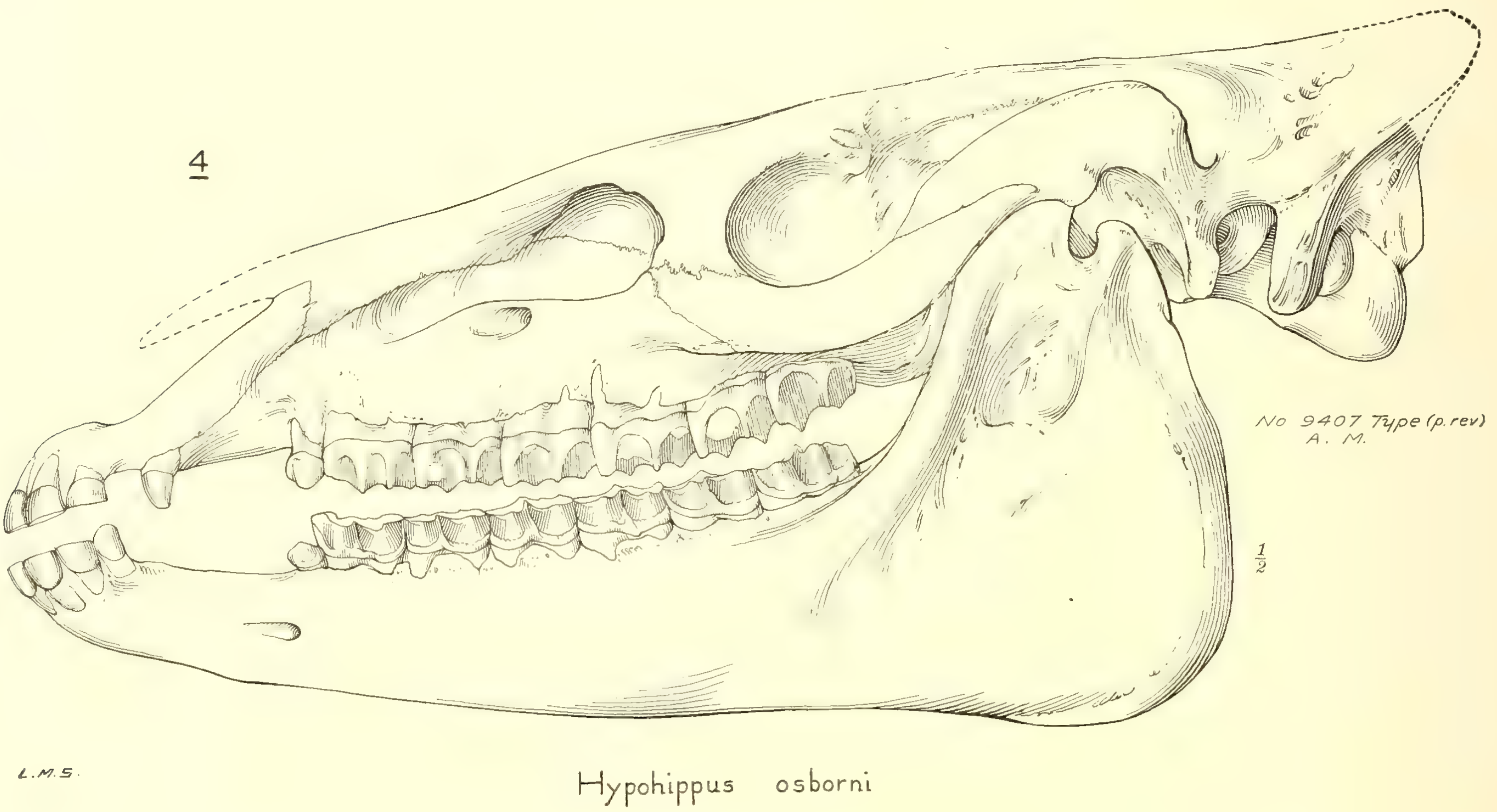


Fig. 167. *Hypohippus equinus* Scott, Princeton Mus. 10404, type. (Upper) Original figure of the skull of the type, one-half natural size. (Left lower) Original figure of the upper and lower dentition of the type; (24) upper, (25) lower. three-fourths natural size. (Right lower) (26) Front view of humerus, one-half natural size; (27) ungual phalanx of D III, two-thirds natural size; (28) phalanges of D II, two-thirds natural size. After Scott, 1894, Pl. iii, figs. 23–28.

scapula) and the pelvis." Measurements: (Scott, 1894) superior molar-premolar series .147; superior premolar series .083; inferior premolar-molar series .148.

Type figure.— Text Fig. 167 of this Memoir.

Characters.— (Scott, *Trans. Am. Philos. Soc.* 1894, pp. 94, 95) "From the best-known European species, *A. aurelianense,* it differs in the following respects; (1) Larger size of the teeth in proportion to the skeleton; (2) absence of enamel invaginations in the lower incisors; (3) smaller size of the antero-external buttress on p²; (4) the transverse crests of the upper molars and premolars are less sinuous; (5) p_2 has the anterior half of the crown flattened on the outside and no external valley; (6) the diastema between the lower canine and p_1 is relatively shorter and the symphysis is much narrower; (7) the proximal end of the humerus differs in details that will be explained in the full description; (8) the median digit is more enlarged and its ungual phalanx shorter and more rounded, but also flatter and more depressed."



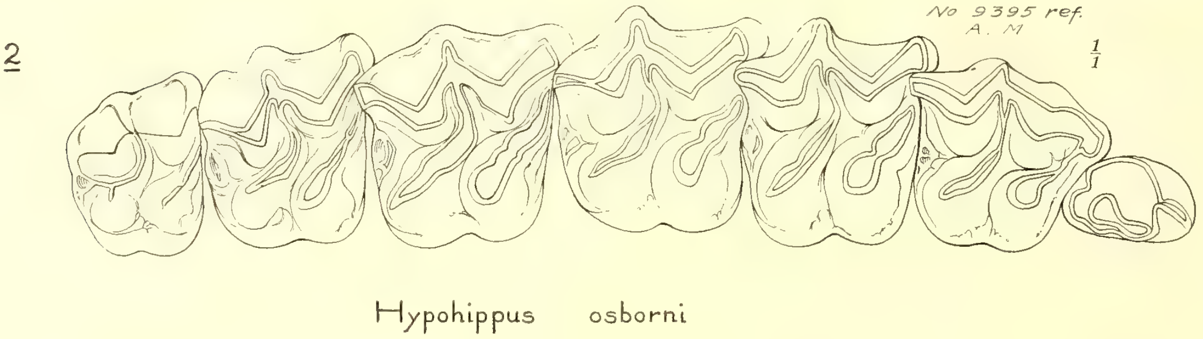


Fig. 168. (4) Skull of the type of *Hypohippus osborni* Gidley, Amer. Mus. 9407. One-half natural size. (2) Superior molars of *H. osborni* Gidley, Amer. Mus. 9395, a referred specimen. Natural size.

MERYCHIPPUS PANIENSIS-M. SEJUNCTUS ZONE. 10. EARLY MIDDLE MIOCENE.

THIS ZONE IS TYPIFIED BY THE PAWNEE CREEK, NORTHEASTERN COLORADO.

Hypohippus osborni Gidley 1907.

Plates 5.9, 6.4, 35.2,4, 39.8,11, 51.2,5. Text Figs. 51, 168.

Hypohippus osborni sp. nov., Gidley, James W. "Revision of the Miocene and Pliocene Equidæ of North America," *Bull. Amer. Mus. Nat. Hist.*, Vol. XXIII, Art. XXXV, Nov. 26, 1907, pp. 930, 931, no figure.

Horizon and locality.— Middle Miocene, Pawnee Creek formation, Merychippus and Ticholeptus zone, Pawnee beds, northeastern Colorado. Type collected by Barnum Brown, Amer. Mus. Expedition of 1901.

Type.— Amer. Mus. 9407. A skull and nearly complete skeleton. Measurements: (Gidley) p^1–m^3 .151; molar series, m^{1-3}, .069; total length of skull .371. *Paratype.* Amer. Mus. 9395, a palate with complete dentition, associated with lower jaws and other parts of the skeleton.

Type figure.— Plates 5.9, 6.4, 35.4, 39.8, 11, 51.2,5, text Figs. 51, 168 of this Memoir.

Characters.— (Gidley, 1907) "As indicated by the teeth, this species is intermediate in size and progressive development between *H. affinis*, the type of the genus, and *H. equinus* (Scott), the latter being the smallest and least specialized. Compared with *H. equinus* the principal differences are, (1) cheek teeth relatively longer crowned; (2) outer walls of upper cheek teeth more deeply curved; (3) protocone and hypocone more compressed anteroposteriorly; and (4) the incisors are relatively wider. . . . The unusually complete skeleton on which the genus *Neohipparion* (*N. whitneyi*) was founded affords an opportunity for an interesting comparison of two wholly different types of horses. In general proportions *H. osborni* is longer necked, longer bodied and shorter limbed than *N. whitneyi*. The relatively smaller head with its brachyodont uncemented teeth, its less vertical depth, its more anteriorly placed orbits which are not inclosed behind, presents a totally different appearance from that of *N. whitneyi* which is very much nearer the typical modern horse. A comparison of the feet also shows some marked differences. In *H. osborni* the lateral toes are long and slender, the lateral ones being so greatly reduced as to render the foot practically monodactyl."

A referred specimen is Amer. Mus. 9395.

PROCAMELUS-HIPPARION ZONE. LOWER PLIOCENE.

Hypohippus affinis Leidy 1858.

Plate 35.1. Text Fig. 169.

Anchitherium (*Hypohippus*) *affinis*, Leidy, Joseph. "Notice of Remains of Extinct Vertebrata, from the Valley of the Niobrara River, collected during the Exploring Expedition of 1857, in Nebraska, under the command of Lieut. G. K. Warren, U. S. Top. Eng., by Dr. F. V. Hayden, Geologist to the Expedition," *Proc. Acad. Nat. Sci. Phila.* Vol. X, 1858, p. 26, no figure. *Hypohippus affinis*, "The Extinct Mammalian Fauna of Dakota and Nebraska," *Jour. Acad. Nat. Sci. Phila.* (2) Vol. VII, 1869, p. 311, Pl. xxi, figs. 11, 12.

Horizon and locality.— Lower Pliocene, "Nebraska formation," Hipparion and Procamelus zone, Niobrara River, near Ft. Niobrara, Nebraska. Name of collector not given.

Type.— U. S. National Mus. 573 (cast, Amer. Mus. 10771). Fourth upper milk premolar, dp^4, of left side. Measurements: (Gidley, 1906) Nat. Mus. 573, dp^4 a.p. .027, tr. .029. Another specimen is referred by Gidley, Amer. Mus. 10834, also found in the Lower Pliocene, Nebraska formation at Big Spring Cañon. Measurements: p_3 a.p. .028, tr. .020; p_4, .0275, tr. .021, height of crown, inside, .020, outside .025; m_1 .0285, tr. .020.

Type figure.— Text Fig. 169 of this Memoir.

Characters.— (Leidy, 1858, p. 26.) " . . . .has the same form [of upper molar] as the corresponding teeth of *Anchitherium,* except that the outer surfaces of its external lobes present no trace of median rising. It indicates an animal larger than *A. aurelianense* and about the size of *Palæotherium crassum.*"

(Gidley, 1906, pp. 135, 136) "Compared with the corresponding teeth in *H. equinus* they show a marked progressive stage, especially in (1) their greater size; (2) their proportionately longer crowns; and (3) the better development of the metastylid which at its summit in the little worn teeth is slightly separated from the metaconid by a shallow groove which extends but a short distance down the side of the metaconid pillar. The continuous external basal cingulum is well developed in a broad heavy band of enamel."

(Gidley, 1906) Only on the ground of equality in size, the height of the molar crowns, and its derivation from the same formation and a locality not far removed from that of the type is the reference to this species of the lower teeth from Big Spring Cañon made. 14043 A. M.

A referred specimen is Amer. Mus. 14043.

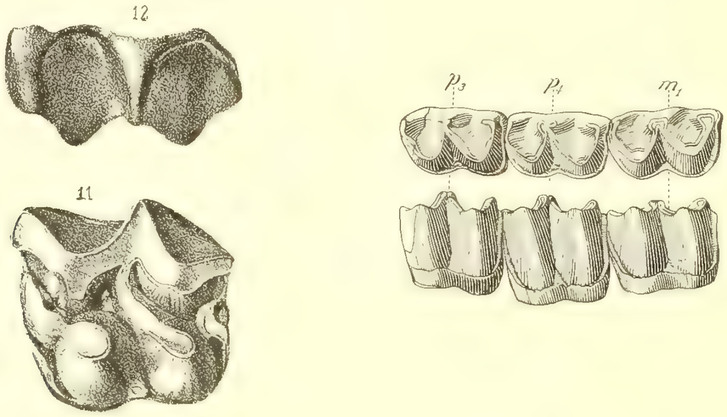


Fig. 169. *Hypohippus affinis* Leidy, U. S. National Mus. 573. (11, 12) Original figures of the type, natural size. After Leidy, 1869, Pl. xxi, figs. 11, 12. (Right) Referred lower teeth, Amer. Mus. Nat. Hist. 10834. One-half natural size. After Gidley, 1906, fig. 1, p. 135.

Hypohippus nevadensis Merriam 1913.

Text Fig. 170.

Hypohippus (*Drymohippus*) *nevadensis,* n. sub-gen. and n. sp., Merriam, John C. "New Anchitheriine Horses from the Tertiary of the Great Basin Area," *Univ. Cal. Publ. Bull. Dept. Geol.,* Vol. 7, No. 22, Dec. 16, 1913, pp. 420, 422, figs. 1*a*, 1*b*, 2*a*, 2*b*.

Horizon and locality.— (Merriam) "From the Stewart Valley Miocene, twenty-four miles northeast of Mina, Nevada." Procamelus zone. Type collected by T. Holman Buck.

Type.— Univ. Cal. Pal. Coll. 21056. (Merriam) "The type specimen consists of a small portion of the skull with three milk molars, portions of all four limbs, and a number of scattered fragments of other skeletal parts. The elements of the limbs were in part connected." Measurements: (Merriam) dp^2 a.p. .033, tr. .029; dp^3 a.p. .0318, tr. .0305; dp^4 a.p. .0319, tr. .0314.

Type figure.— Text Fig. 170 of this Memoir.

Characters.— (Merriam, 1913, p. 421) (1) An animal approaching in size *H. affinis,* the largest described species. (2) Milk teeth exceeding in dimensions those of *H. osborni;* (3) deciduous crown pattern in general resembling that of permanent crown pattern in *H. osborni;* (4) metaloph not connected with ectoloph; (5) a crista extending inward from ectoloph; (6) Limbs in general character and proportions near those of *Hypohippus;* (7) The proposed subgenus *Drymohippus* distinguished from *Hypohippus* by the separation of the metaloph from the ectoloph in the milk dentition.

Hypohippus matthewi Barbour 1914.

Text Fig. 171.

Hypohippus matthewi, Barbour, Erwin H. "A New Fossil Horse, Hypohippus Matthewi," *Nebraska Geol. Survey*, Vol. 4, Part 10, June 10, 1914, pp. 169–173, pl. I.

Horizon and locality.— Devil's Gulch, Brown County, western Nebraska. Upper Miocene or Lower Pliocene. Type collected by A. C. Whitford.

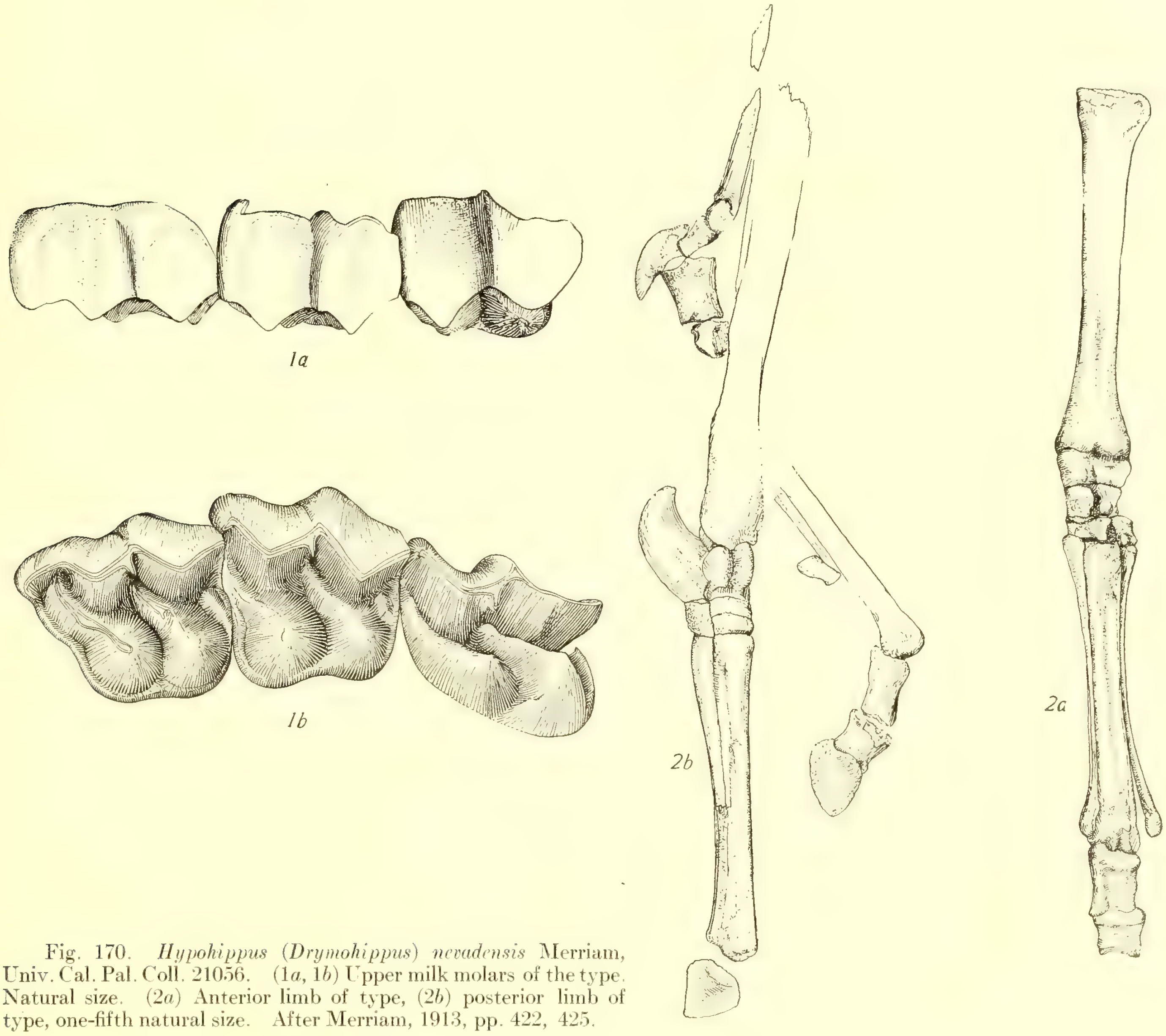


Fig. 170. *Hypohippus (Drymohippus) nevadensis* Merriam, Univ. Cal. Pal. Coll. 21056. (*1a*, *1b*) Upper milk molars of the type. Natural size. (*2a*) Anterior limb of type, (*2b*) posterior limb of type, one-fifth natural size. After Merriam, 1913, pp. 422, 425.

Type.— Univer. Nebraska Coll. 10–16–5–13 (Barbour, p. 171) "The material on which this new species is based, consists of the right maxilla with four perfect teeth, and the left, with three, together with strong incisors. . . . The teeth figured in this report were found 6 feet below the level of the mastodon skull, which we have named *Mastodon morrilli*." Measurements: (Barbour, p. 172) p^2 a.p. .038; p^3 a.p. .037, tr. .041, height of crown .036; p^4 a.p. .035, tr. .043, height of crown .036; m^1 a.p. .036, tr. .041, height of crown .029. *Referred specimens.* In addition scattered lower teeth, numerous limb bones, and several nearly complete feet were found and referred to this species.

Type figure.— Text Fig. 171 of this Memoir.

Characters.— (Barbour, p. 171) (1) The largest member of the genus known as yet, from one-fourth to one-eighth larger than *H. affinis.* (2) Teeth noticeably more hypsodont; (3) teeth resembling those of *Mesohippus bairdii* grown enormously large; (4) strong internal and external cingula on p$^{2-4}$, cingula less apparent on m^1; (5) a cement reinforcement half way up the crowns; (6) metaloph uniting with ectoloph opposite mesostyle; (7) protoloph disconnected from ectoloph in premolars but somewhat less in molars; (8) fossettes deep, bounding walls nearly vertical; (9) hypostyle rudimentary, an elongate, loop-like expansion of postcingulum.

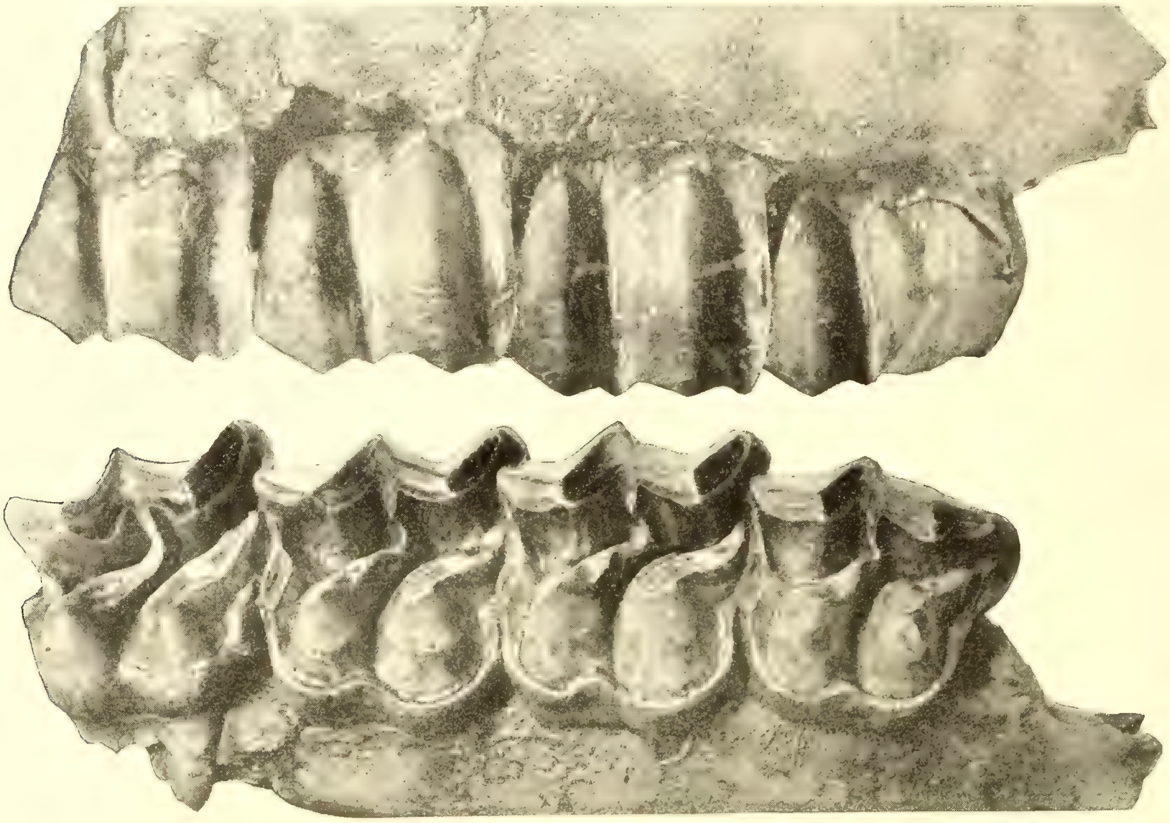


Fig. 171. Original figure of the type of *Hypohippus matthewi* Barbour, Morrill Coll. Univ. of Nebraska, 10–16–5–13, superior dentition, p^2–m^1. Natural size. After Barbour, 1914, Pl. 1.

A fore foot (Barbour, *op. cit.*, 1914, pl. II) referred by Barbour to this species belongs to a species of *Merychippus.*

GENUS **ARCHÆOHIPPUS** GIDLEY 1906.

Bull. Amer. Mus. Nat. Hist. Vol. XXII, Art. XXII, Dec. 19, 1906, pp. 385–388.

Genotype.— *Archæohippus* (*Anchitherium*) *ultimus* Cope, from the Mascall, Middle Miocene, Ticholeptus zone of Cottonwood Creek, Oregon. This genus is represented by only two species at present, *A. ultimus* and *A. mourningi*, from the Middle Miocene of Oregon and Upper Miocene of California, and is known only from the anterior portion of a skull and the grinding teeth.

The chief characters are the following:

1. Grinding teeth short-crowned, protoloph and metaloph continuous, protocone partly distinct, sharply crested cones and conules, purely lophoid, not bunoid.
2. Internal cingulum vestigial or wanting.
3. Crochet absent, hypostyle undeveloped.
4. M$\frac{3}{3}$ not reduced.
5. Facial region relatively longer than in *Hypohippus*, orbits placed farther back.
6. Preorbital lachrymo-malar fossa very deep.
7. Anterior border of orbit above m^3.
8. Incisor teeth small.
9. "P_4 probably not larger than m_1, as indicated by the comparatively large upper true molars." (Gidley, 1907, p. 868.)

TICHOLEPTUS-MERYCHIPPUS RELICTUS ZONE. 9. EARLY MIDDLE PLIOCENE.

THIS ZONE IS TYPIFIED BY THE MASCALL OF OREGON.

Archæohippus ultimus Cope 1886.

Plate 6.2. Text Fig. 172.

Anchitherium ultimum, sp. nov., Cope, E. D. "On Two New Species of Three-toed Horses from the Upper Miocene, with Notes on the Fauna of the Ticholeptus Beds," *Proc. Amer. Philos. Soc.* Vol. XXIII, April 15, 1886, pp. 357–358, no figure. *Archæohippus ultimus* (Cope), Gidley, J. W., "A New Genus of Horse from the Mascall Beds, with Notes on a Small Collection of Equine Teeth in the University of California," *Bull. Amer. Mus. Nat. Hist.* Vol. XXII, Art. XXII, Dec. 19, 1906, pp. 385–388, figs. A, B.

Horizon and locality.— Middle Miocene, Mascall formation, Cottonwood Creek, Ore., Ticholeptus zone. Type collected by J. L. Wortman.

Type.— Amer. Mus. Cope Coll. 8174. Anterior portion of a skull, with nearly complete dentition. Measurements: (Cope) superior molar series .079; true molars m$^{1-3}$ .034; m^1 a.p. .011, tr. .015; m^3 a.p. .011, tr. .014.

Type figure.— Plate 6.2, text Fig. 172 of this Memoir.

Characters.— (Cope, 1886, Osborn, 1918) (1) Size diminutive. (2) Dental series of same length as that of *Miohippus longicristis*; (3) premolars and molars with well marked external cingulum and internal cingulum around base of p^2; (4) weak cingulum around protolophs of m$^{2-3}$; (5) long diastema between canine and p^1. (6) A deep and large preorbital fossa separated from the orbit by a vertical ridge; (7) anterior border of orbit above anterior border of m^3, agreeing only with *Kalobatippus præstans;* (8) antorbital foramen above middle of fourth premolar; (9) lateral narial opening extending very far back. (Gidley, 1906, p. 386) (10) Complete union of metaloph with ectoloph; (11) proportionately larger size of protoconule; (12) crochet on metaloph absent or slightly developed; (13) comparatively equal proportions of molars and premolars; (14) presence of all developed internal basal cingulum. (15) Elongation of preorbital region of the skull; (16) backward position of the orbit; (17) great development of lachrymo-malar fossæ.

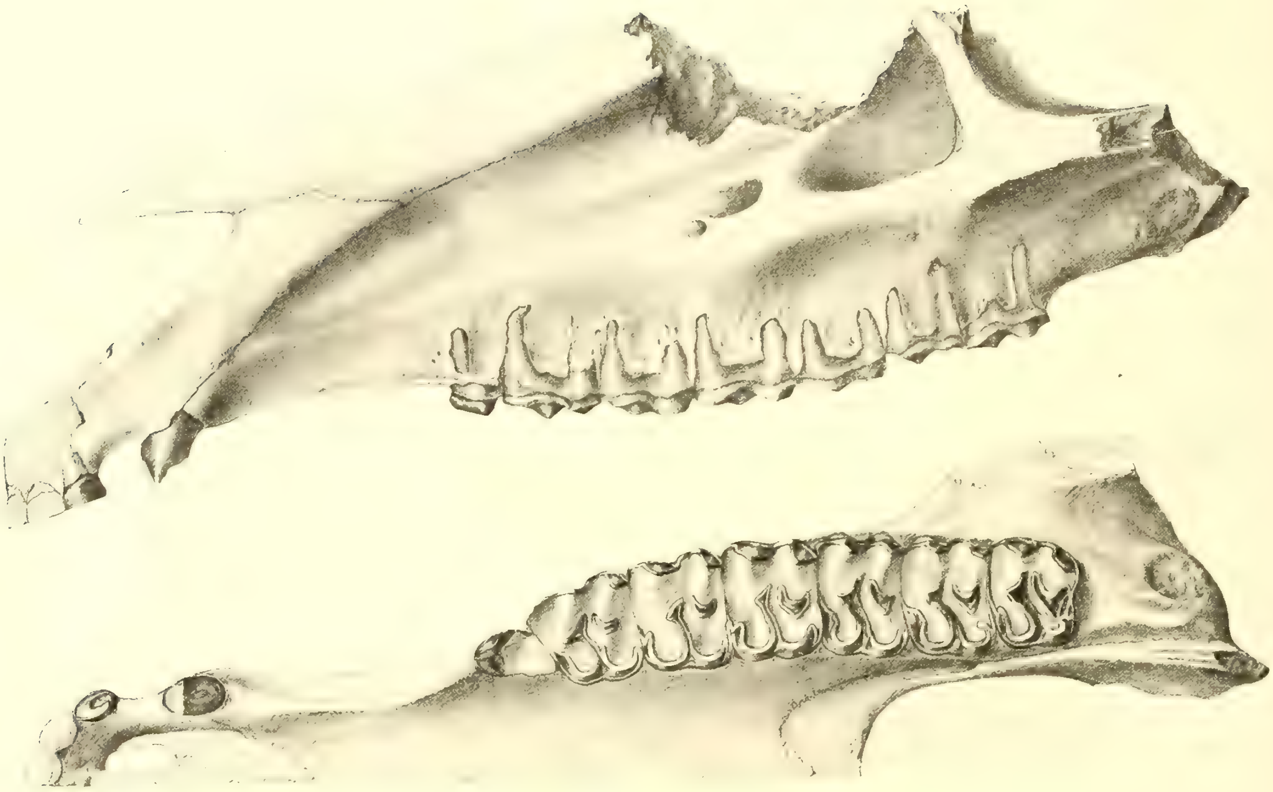


Fig. 172. Type of *Archæohippus ultimus* Cope, Amer. Mus. 8174, lateral and palatal views. Natural size. Drawing by B. Yoshihara.

PROCAMELUS–MERYCHIPPUS CALAMARIUS ZONE. 11. LATE MIDDLE MIOCENE.

This zone is typified by the Barstow of California and Santa Fé of New Mexico.

Archæohippus mourningi Merriam 1913.

Text Fig. 173.

Parahippus (?) *mourningi*, n. sp., Merriam, John C. "New Anchitheriine Horses from the Great Basin Area," *Univ. Cal. Publ. Bull. Dept. Geol.* Vol. 7, No. 22, Dec. 16, 1913, p. 427, fig. 3.

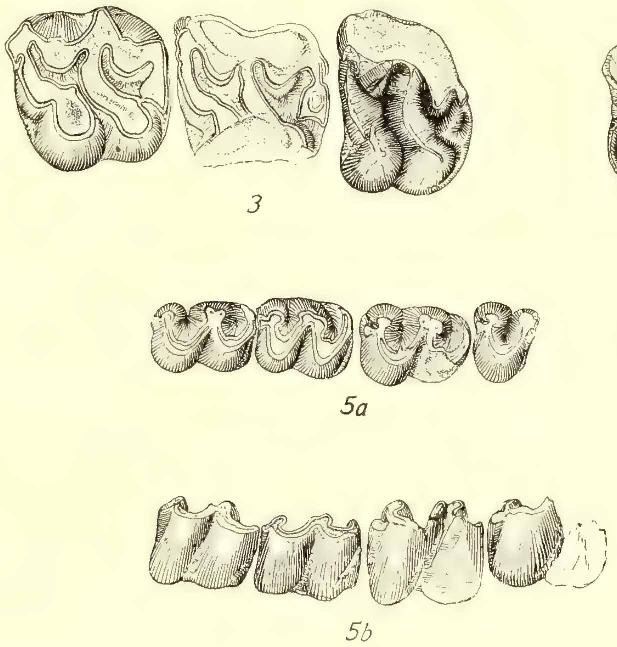


Fig. 173. (3) Original figure of the type of *Archæohippus mourningi* Merriam, Univ. Cal. Pal. Coll. 19840, dp^{3-4}, m^1. One and one-half natural size. (4) *A. ultimus* Cope, Univ. Cal. Pal. Coll. 1689, referred upper molar. One and one-half natural size. (*5a*, *5b*) Paratype of *A. mourningi* Merriam, Univ. Cal. Pal. Coll. 19764, p_3–m_2. Natural size. After Merriam, 1913, pp. 422, 428.

Horizon and locality.— Barstow formation, Barstow syncline, Mohave Desert, California. Type collected by H. S. Mourning, Jan. 1913.

Type.— Univ. Cal. Pal. Coll. 19840. A portion of a maxillary with milk dentition and m^1. Measurements: m^1 a.p. .0137, tr. .016. *Paratype.* A portion of a mandible with dentition representing p_2–m_2, Univ. Cal. Pal. Coll. 19764.

Type figure.— Text Fig. 173 of this Memoir.

Characters.— (Merriam, 1913) (1) Small, brachyodont horse. (2) Metaloph fully united with ectoloph; (3) protoloph elongate and lophoid, overlapping left protocone; (4) hypostyle subtriangular; (5) crochet represented by several plate-like projections from outer end of metaloph; (6) cingulum well developed on posterior side; (7) surface of crown somewhat rugose without trace of cement.

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  Neohipparion, see Hipparion
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  Pliohippus, pp. 146–172
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" " " cranium and skeleton, under respective species, and pp. 3–7
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	Present Generic Ref.	Original Generic Ref.
acutidens Sinclair 1905,	Miohippus	(Mesohippus), pp. 52, 64–65.
affine Leidy 1869,	Hipparion	(Hipparion), pp. 174, 178–179.
affinis Leidy 1858,	Hypohippus	(Anchitherium (Hypohippus) affinis), pp. 204, 207–208
agatensis Osborn sp. nov.	Kalobatippus	pp. 69, 71–73
agrestis Leidy 1873,	Parahippus	(Anchitherium agreste), pp. 75, 86–87
anceps Marsh 1874,	Miohippus	(Anchitherium), pp. 52, 58
annectens Marsh 1874,	Miohippus	(Miohippus), pp. 52, 63–64
anthonyi Merriam 1916,	Hipparion	(Hipparion), pp. 174, 189
assiniboiensis Lambe 1905,	Mesohippus	(Mesohippus), pp. 37, 41
atavus, see pawniensis		
australis Leidy 1873,	Parahippus	(Anchitherium (?) australe), pp. 75, 85
avus Marsh 1874,	Parahippus	(Protohippus), pp. 75, 87–89
bairdii Leidy 1850,	Mesohippus	(Palæotherium, Anchitherium), pp. 37, 45–46
brachylophus Cope 1878,	Miohippus	(Anchitherium), pp. 52, 60
brachystylus Osborn 1904,	Miohippus	(Mesohippus), pp. 52, 54

SPECIES, alphabetical list of, continued

	PRESENT GENERIC REF.	ORIGINAL GENERIC REF.
brevidens Marsh 1874,	Parahippus	(Anchippus), pp. 75, 89–90
calamarius Cope 1876,	Merychippus	(Hippotherium calamarium), pp. 99, 123–125
? calamarius, propinquus		p. 28
californicus Merriam 1915,	Merychippus	(Merychippus), pp. 99, 121–122
calodonte, see mohavense		
campestris Gidley 1907,	Merychippus	(Merychippus), pp. 99, 114–115
castilli Cope 1885,	Protohippus	(Protohippus), pp. 128, 141–142
celer Marsh 1874,	Mesohippus	(Anchitherium), pp. 36–38
coalingensis Merriam 1914,	Pliohippus	(Protohippus), pp. 147, 165–166
cognatus Leidy 1858,	Parahippus	(Anchitherium (Parahippus)), pp. 75, 94–95
coloradense Osborn sp. nov.	Hipparion	pp. 174, 183–184
coloradensis Gidley 1907,	Parahippus	(Parahippus), pp. 75, 93–94
coloradensis præcurrens Osborn sp. nov.	Parahippus	pp. 75, 83
condoni Leidy 1871,	Miohippus	(Anchitherium), pp. 52, 63
condoni Merriam 1915,	Hipparion	(Hipparion), pp. 174–176
copei Osborn and Wortman 1895,	Colodon, Miohippus crassicuspis	(Mesohippus), pp. 52, 57–58
cumminsii Cope 1893,	Pliohippus	(Equus), pp. 147, 168–169
cuneatus Cope 1873,	Mesohippus	(Anchitherium), pp. 37, 47
crassicuspis Osborn 1904,	Miohippus	(Miohippus), pp. 52, 57–58
crenidens Scott 1893,	Parahippus	(Desmatippus), pp. 75, 90–92
dolichops Gidley 1906,	Hipparion	(Neohipparion), pp. 174, 182–183
eohipparion Osborn sp. nov.	Merychippus	pp. 20, 99, 117–119
eoplacidus Osborn sp. nov.	Merychippus	pp. 20, 99, 114, 117
equiceps Cope 1878,	Miohippus	(Anchitherium), pp. 52, 59–60
equinanus Osborn sp. nov.	Miohippus	pp. 52, 65–66
equinus Scott,	Hypohippus	(Anchitherium equinum), pp. 203–206.
eulophus Osborn 1904,	Mesohippus	(Mesohippus), pp. 37, 49
eurystyle Cope, 1893,	Hipparion	(Equus), pp. 174, 186–187
exoletus Cope 1873	Mesohippus	(Anchitherium exoletum), pp. 37, 47
fairbanksi Merriam 1915,	Pliohippus	(Pliohippus), pp. 147, 164
fossulatus Cope 1893,	Pliohippus	(Protohippus), pp. 147, 156–158
fraternus, Leidy, (see Hipparion princeps)		
gemmarosæ Osborn sp. nov.	Miohippus	pp. 52, 66–68
gidleyi Osborn 1904,	Miohippus	(Mesohippus), pp. 52, 56–57
gidleyi Merriam 1915,	Hipparion	(Neohipparion), pp. 174, 187–188
gracilis Marsh 1892,	Kalobatippus	(Pliohoppus), pp. 69, 71
gracile Kaup 1833,	Hipparion	(Equus (Hippotherium) gracilis), Pl. 39.5
gratum Leidy 1869,	Hipparion	(Hipparion), pp. 174, 179–180
gratum tehonense Merriam 1916,	Hipparion	(Neohipparion), pp. 174, 190
hypostylus Osborn 1904,	Mesohippus	(Mesohippus), pp. 37, 41
ingenuum Leidy 1885,	Hipparion	(Hippotherium), pp. 174, 191
insignis Leidy 1857,	Merychippus	(Merychippus), pp. 99, 122–123
? insignis obliquus		p. 28
intermedius Osborn and Wortman 1895,	Miohippus	(Mesohippus), pp. 25, 54
intermontanus Merriam 1915,	Merychippus	(Merychippus), pp. 99, 121
interpolatus Cope 1893,	Pliohippus	(Hippidium interpolatum), pp. 147, 158, 160
isonesus Cope 1889,	Merychippus	(Hippotherium isonesum Cope, H. seversum Cope), pp. 99, 101–103
" primus Osborn sp. nov.	Merychippus	pp. 99, 102, 104
" secundus Osborn sp. nov.	"	pp. 99, 105
" tertius Osborn sp. nov.	"	pp. 99, 105–106
" quartus Osborn sp. nov.	"	pp. 99, 107
" quintus Osborn sp. nov.	"	pp. 99, 107–108
labrosus Cope 1874,	Merychippus	(Protohippus), pp. 99, 109–110
latidens Douglass 1904,	Mesohippus	(Mesohippus), pp. 37, 39
leidyanus Osborn sp. nov.	Pliohippus,	pp. 147, 162–163
lenticulare Cope 1893,	Hipparion	(Protohippus), pp. 174, 184–185
leonensis Sellards 1916,	Parahippus	(Parahippus), pp. 75, 95–96
leptode Merriam 1915,	Hipparion	(Neohipparion), pp. 174, 197
longicristis Cope 1878,	Miohippus	(Anchitherium), pp. 52, 61
lullianus Troxell 1916,	Pliohippus	(Pliohippus), pp. 147, 159–160
matthewi Barbour 1914,	Hypohippus	(Hypohippus), pp. 204, 209–210
meteulophus Osborn 1914,	Miohippus	(Mesohippus), pp. 51–53
minimus Douglass 1908,	Parahippus	(Anchitherium), pp. 75, 96–97
minor Sellards,	Hipparion	(Hipparion), pp. 174, 192–193
minutus Cope 1893,	Pliohippus	(Equus), pp. 147, 169–170

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	Present Generic Ref.	Original Generic Ref.
mirabilis Leidy 1858,	Pliohippus	(Merychippus), pp. 147–148
missouriensis Douglass 1908,	Merychippus	(Meryshippus?), pp. 99, 119–120
mohavense Merriam 1913,	Hipparion	(Hipparion (?)), pp. 174, 193–194
mohavense callodonte Merriam 1915,	Hipparion	(Hipparion), pp. 174, 194–195
molle Merriam 1915,	Hipparion	(Neohipparion), pp. 174, 196
montezuma Leidy 1883,	Hipparion	(Hippotherium), pp. 174, 197
mourningi Merriam 1913,	Archæohippus	(Parahippus (?)), pp. 204, 213
nebrascensis Peterson 1907,	Parahippus	(Parahippus), pp. 75, 79–80
nebrascensis primus Osborn sp. nov.	Parahippus,	pp. 75, 80, 82
nevadensis Merriam 1913,	Hypohippus	(Hypohippus (Drymohippus) nevadensis), pp. 204, 208
niobrarensis Gidley 1906,	Protohippus	(Neohipparion), pp. 128, 135
nobilis osborn sp. nov.	Pliohippus,	pp. 147, 160–161
obliquidens Osborn 1904,	Mesohippus	(Mesohippus), pp. 37, 48–49
obliquus, see ? insignis		
occidentale Leidy 1856,	Hipparion	(Hipparion), pp. 174, 176–177
osborni Gidley 1907,	Hypohippus	(Hypohippus), pp. 204, 207
pachyops Cope 1893,	Protohippus	(Protohippus), pp. 128, 138–139
paniensis Cope 1874,	Merychippus	(Hippotherium paniense), pp. 99, 109
parvulus Marsh 1868,	Protohippus	(Equus), pp. 128, 130, 132–133
patruus Osborn sp. nov.	Merychippus,	pp. 99, 126
pawniensis Gidley 1907,	Parahippus	(Parahippus), pp. 75, 92–93
pawniensis atavus Osborn sp. nov.	Parahippus,	pp. 75, 80–81
peninsulatum Cope 1885,	Hipparion	(Hippotherium), pp. 174, 198–199
perditus Leidy 1858,	Protohippus	(Equus (Protohippus) perditus), pp. 128–131
perditus secundus Osborn sp. nov.	Protohippus	pp. 128, 144–145
pernix Marsh 1874,	Pliohippus	(Pliohippus), pp. 147, 151–155
phlægon	See Pliohippus minutus Cope,	pp. 147, 169–170
placidus Leidy 1869,	Protohippus	(Protohippus), pp. 128, 133–135
planidens Lambe, 1905,	Mesohippus	(Mesohippus), pp. 37, 44
platystyle Merriam 1915,	Hipparion	(Neohipparion, Hippotherium), pp. 174, 188
plicatile Leidy 1887,	Hipparion	(Hippotherium), pp. 174, 192
portentus Douglass, 1908,	Mesohippus	(Mesohippus), pp. 37, 40–41
præcocidens Lambe, 1905,	Mesohippus	(Mesohippus), pp. 37, 42–43
præcurrens, see coloradensis		
præstans Cope 1879,	Kalobatippus	(Anchitherium), pp. 69, 70–71
primus Osborn sp. nov.	Miohippus	pp. 52, 61–62
primus, see isonesus		
primus, see nebrascensis		
princeps Leidy 1890,	Equus	(Hippotherium, Hipparion), pp. 174, 201–202
pristinus Osborn sp. nov.	Parahippus	pp. 75, 76–77
profectus Cope 1889,	Protohippus	(P. or H. profectus), pp. 128, 142–144
proparvulus Osborn sp. nov.	Merychippus	pp. 20, 99, 117–118
propinquus Lambe 1905,	Mesohippus	(Mesohippus), pp. 37, 42–43
propinquus, see calamarius		
proplacidus Osborn sp. nov.	Protohippus	pp. 128, 139–141
proteulophus Osborn 1904,	Mesohippus	(Mesohippus), pp. 37, 41–42
proversus Merriam 1917	Pliohippus	(Pliohippus), pp. 147, 170–172
quartus Osborn sp. nov.	Miohippus	pp. 52, 62–63
quartus, see isonesus		
quintus, “ “		
rectidens Cope 1886,	Hipparion	(Hippotherium), pp. 174, 199–200
relictus Cope 1889,	Merychippus	(Hippotherium relictum), pp. 99, 100
republicanus Osborn sp. nov.	Merychippus	pp. 99, 125–126
retrusus Cope 1889,	Protohippus	(Hippotherium retrusum), pp. 128, 142–143
robustus Marsh,	Pliohippus	(Pliohippus), pp. 155–156
secundus, see isonesus		
secundus, see perditus		
sejunctus Cope 1874,	Merychippus	(Protohippus), pp. 99, 110–112
seversus Cope 1878,	Merychippus	(Stylonus seversus), pp. 99, 101–102
simplicidens Cope 1892,	Pliohippus	(Equus), pp. 147, 167–168
simus Gidley 1906,	Protohippus	(Protohippus), pp. 128, 135, 137
sinclairi Wortman 1882,	Hipparion	(Hippotherium), pp. 174, 195–196
sp. Sellards 1916,	Merychippus	(Merychippus), pp. 99, 108
sp.,	Mesohippus Pl. 2.12	
sp.,	Parahippus, Pl. 37, 39.3	
sp.,	Merychippus, Pl. 25.6	
sp.,	Pliohippus, Pl. 39.6, 7	

SPECIES, alphabetical list of, continued

	PRESENT GENERIC REF.	ORIGINAL GENERIC REF.
speciosus Leidy 1854,	Hippodon	(see Protohippus) (Hippodon), pp. 128, 129
spectans Cope 1880,	Pliohippus	(H. spectans), pp. 147, 164–165
sphenodus Cope 1889,	Merychippus	(Hippotherium), pp. 99, 112–113
speciosum, see republicanus	Merychippus	(Hippotherium speciosum Leidy), pp. 99, 125–126
stenolophus Lambe 1905,	Mesohippus	(Mesohippus), pp. 37, 43–44
Stylodus Merriam, 1915	Merychippus calamarius	(Merychippus stylodus), pp. 99, 125
sumani Merriam 1915,	Merychippus	(Merychippus), pp. 99, 120–121
supremus Leidy 1869,	Pliohippus	(Protohippus), pp. 147, 149–150
tantalus Merriam 1913,	Pliohippus	(Pliohippus?), pp. 147, 162–163
taxus Douglass 1908,	Parahippus	(Altippus), pp. 75, 85–86
tertius, see isonesus tehonense, see gratum		
tehonensis Merriam 1915,	Protohippus	(Protohippus), pp. 128, 138–139
texanus Leidy 1868,	Parahippus	(Anchippus), pp. 75, 84
trigonostylus Osborn sp. nov.	Mesohippus,	pp. 37, 47–48
tyleri Loomis 1908,	Parahippus	(Parahippus), pp. 75, 77–78
ultimus Cope 1886,	Archæohippus	(Anchitherium ultimum), pp. 204, 211–212
validus Osborn 1904,	Miohippus	(Mesohippus), pp. 52, 55–56
var. isonesus	Merychippus,	Pl. 10.3
var.	Mesohippus	Pl. 2.13
venustum Leidy 1859,	Hipparion	(Hippotherium), pp. 174, 200–201
westoni Cope 1889,	Mesohippus	(Anchitherium), pp. 37–39
whitneyi Gidley 1903,	Hipparion	(Neohipparion), pp. 174, 181
zitelli Schlosser 1903	Hypohippus	(Anchitherium), Pl. 35.3

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" " , tables of, in chronologic order, pp. 37, 52, 69, 75, 99, 128, 147, 174, 204

PLATES.

KEY TO PLATES.

The teeth in all the Plates are drawn natural size.
The skulls are drawn one-half natural size.
The limbs and feet are drawn one-half natural size.

PLATE 1 SKULLS: *MESOHIPPUS, MIOHIPPUS*
“ 2 UPPER TEETH: *MESOHIPPUS*
“ 3 UPPER TEETH: *MIOHIPPUS*
“ 4 UPPER AND LOWER TEETH: *MIOHIPPUS*
“ 5 TEETH, FEET: *MIOHIPPUS, HYPOHIPPUS*
“ 6 FACE: *MIOHIPPUS, ARCHÆOHIPPUS*, ETC.
“ 7 SKULL: *PARAHIPPUS*
“ 8 UPPER AND LOWER TEETH: *PARAHIPPUS*
“ 9 “ “ “ “ “
“ 10 FACE: *MERYCHIPPUS*
“ 11 “ “ , OF PROGRESSIVE TYPE
“ 12 SKULL: *MERYCHIPPUS SPHENODUS*
“ 13 UPPER TEETH: *MERYCHIPPUS*
“ 14 UPPER AND LOWER TEETH: *MERYCHIPPUS*
“ 15 UPPER TEETH: *MERYCHIPPUS*
“ 16 “ “ “
“ 17 “ “ “
“ 18 SUPERIOR–INFERIOR MOLAR TOOTH TYPE: *MERYCHIPPUS*
“ 19 LOWER TEETH: *MERYCHIPPUS*
“ 20 SKULL AND LOWER TEETH: *MERYCHIPPUS*
“ 21 FACE: *PROTOHIPPUS*
“ 22 TYPE TEETH: *PROTOHIPPUS*
“ 23 FACE: *PROTOHIPPUS, PLIOHIPPUS*
“ 24 TEETH: *PROTOHIPPUS, PLIOHIPPUS*
“ 25 MILK TEETH: *PARAHIPPUS–HIPPARION*
“ 26 FACE: *MERYCHIPPUS, PLIOHIPPUS*
PLATE 27 TYPE, *PLIOHIPPUS LULLIANUS*
“ 28 UPPER TEETH: *PLIOHIPPUS*
“ 29 TYPE, *PLIOHIPPUS LEIDYANUS*
“ 30 “ “ “
“ 31 TEETH: *PLIOHIPPUS, HIPPARION*
“ 32 FACE: *HIPPARION*
“ 33 TEETH: *PLIOHIPPUS, HIPPARION*
“ 34 MILK TEETH: *MERYCHIPPUS, PROTOHIPPUS, HIPPARION*
“ 35 SKULL AND TEETH: *HYPOHIPPUS*
“ 36 HIND FEET: *PARAHIPPUS*
“ 37 FEET: *PARAHIPPUS*
“ 38 SKELETON: *PARAHIPPUS*
“ 39 CARPUS: MIOCENE HORSES
“ 40 SKELETON: *KALOBATIPPUS*
“ 41 FORE FEET: *MERYCHIPPUS*
“ 42 FEET: “
“ 43 FORE FEET: “
“ 44 “ “ “
“ 45 HUMERUS AND TIBIA: *MERYCHIPPUS*
“ 46 ULNA AND RADIUS: “
“ 47 HUMERUS: “
“ 48 ULNA AND RADIUS: “
“ 49 “ “ “ “
“ 50 FEMUR AND TIBIA: “
“ 51 TARSUS: ANCHITHERIINÆ, *HYPOHIPPUS*
“ 52 HIND FEET: *MERYCHIPPUS*
“ 53 “ “ “
“ 54 “ “ “

PLATE 1.

SKULLS, *MESOHIPPUS*, *MIOHIPPUS*.

PLATE 1.

SKULLS OF *MESOHIPPUS* AND *MIOHIPPUS* FROM THE LOWER, MIDDLE, AND UPPER OLIGOCENE.

All figures natural size.

The *Mesohippus* crania are arranged in ascending systematic and geologic order and exhibit progressive increase in size from the small skulls of the Titanotherium zone to the larger skulls, such as the juvenile *M. obliquidens*, of the Middle Oreodon zone. Indications of the preorbital fossæ are observed in the smallest and most ancient of these horses.

Left column

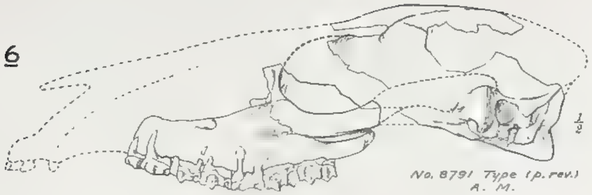
Cheyenne River, So. Dak.	Lower Oligocene	1. *Mesohippus proteulophus* Osborn, referred specimen, Am. Mus. 1208 (reversed in drawing).
“ “ “ “	“ “	2. *M. hypostylus* Osborn, type, Am. Mus. 1180 (partly reversed in drawing).
? ? ? ?	? ?	3. *M. bairdii* Leidy, type. Mus. Cat. No. not known. Type lost.
“ “ “ “	“ “	4. *M. bairdii* Leidy, neotype, Am. Mus. 1477 (partly reversed in drawing).
“ “ “ “	Middle “	5. *M. obliquidens* Osborn, type, Am. Mus. 668 (reconstructed in drawing).
Cedar Creek, Col.	“ “	6. *M. eulophus* Osborn, type, Am. Mus. 8791 (partly reversed in drawing).

Right column.

Cheyenne River, So. Dak.	Upper “	7. *Miohippus meteulophus* Osborn, type, Am. Mus. 1210.
“ “ “ “	“ “	8. *M. brachystylus* Osborn, type, Am. Mus. 11860.
“ “ “ “	“ “	9. *M. intermedius* Osborn and Wortman, type, Am. Mus. 1196.
“ “ “ “	“ “	10. *M. gidleyi* Osborn, type, Am. Mus. 1192.
“ “ “ “	“ “	11. *M. validus* Osborn, type, Am. Mus. 1218.

The smallest of the *Miohippus* crania exceeds in size the largest crania of *Mesohippus* from the Upper Oreodon zone. The *Miohippus* crania exhibit a progressive increase in size. The three skulls from the river channel sandstones of the Protoceras zone, namely, *M. intermedius, M. gidleyi, M. validus*, are believed to be of the same geologic age as the lower levels of the Leptauchenia zone.

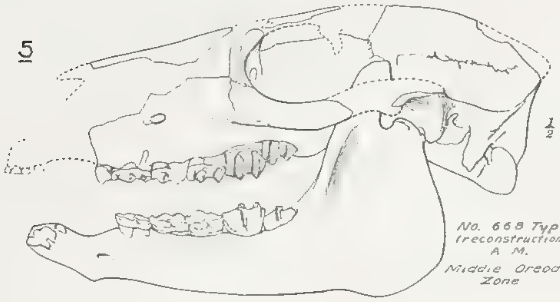
6



No. 8791 Type (p. rev.)
A. M.
Upper Oreodon
Zone

Mesohippus eulophus

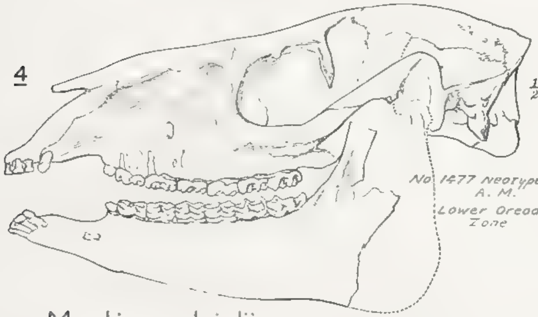
5



No. 668 Type
(reconstruction)
A. M.
Middle Oreodon
Zone

Mesohippus obliquidens

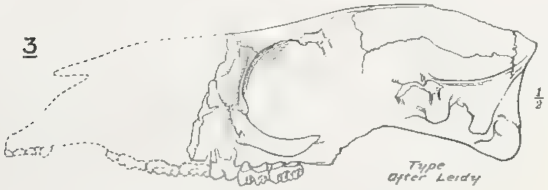
4



No. 1477 Neotype (p. rev.)
A. M.
Lower Oreodon
Zone

Mesohippus bairdii

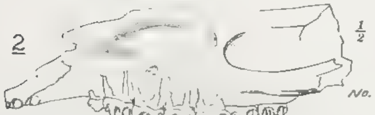
3



Type
After Leidy
? Lower Oreodon
Zone

Mesohippus bairdii

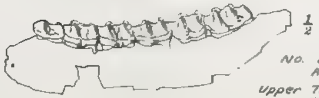
2



No. 1180 Type (p. rev.)
A. M.
Upper Titanotherium
Zone

Mesohippus hypostylus

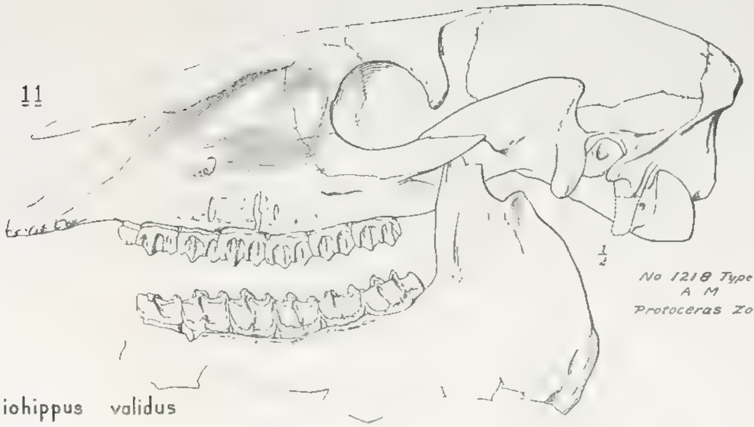
1



No. 1208 (rev.) ref.
A. M.
Upper Titanotherium
Zone

Mesohippus proteulophus

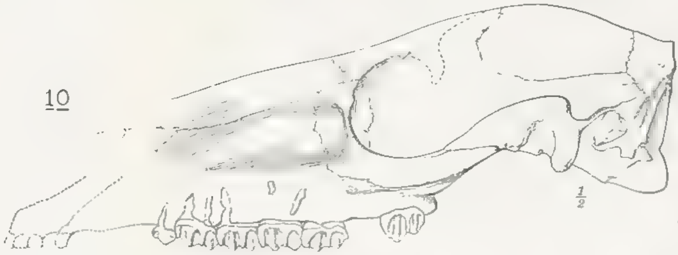
11



No 1218 Type
A M
Protoceras Zone

Miohippus validus

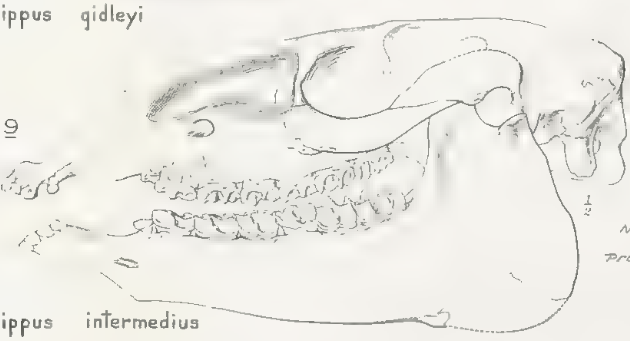
10



No. 1192 Type
A. M.
Protoceras Zone

Miohippus gidleyi

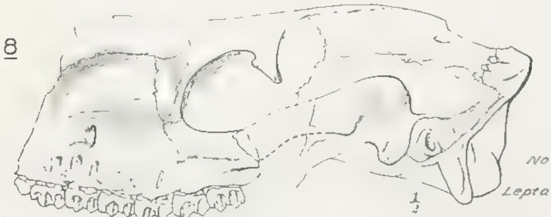
9



No. 1196 Type
A M.
Protoceras Zone

Miohippus intermedius

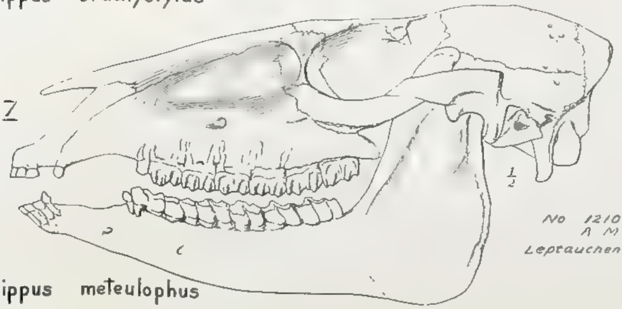
8



No 11860 Type
A M
Leptauchenia Zone

Miohippus brachystylus

7



No 1210 Type
A M
Leptauchenia Zone

Miohippus meteulophus

LMS

PLATE 2.

UPPER TEETH, *MESOHIPPUS.*

PLATE 2.

UPPER TEETH OF *MESOHIPPUS* FROM THE LOWER AND MIDDLE OLIGOCENE.

All figures natural size except 11 which is twice natural size, and 13 which is one-half natural size.

Left column.

Jefferson County, Mont.	Lower Oligocene	1.	*Mesohippus montanensis* Osborn, type, Am. Mus. 9662 (reversed in drawing).
Cheyenne River, So. Dak.	“ “	2.	*M. proteulophus* Osborn, type, Am. Mus. 514a (reversed in drawing).
“ “ “ “	“ “	3.	*M. hypostylus* Osborn, type, Am. Mus. 1180.
“ “ “ “	Middle “	4.	*M. bairdii* Leidy, neotype, Am. Mus. 1477.
“ “ “ “	“ “	5.	*M. trigonostylus* Osborn, paratype, Am. Mus. 673.
“ “ “ “	“ “	6.	*M. trigonostylus* Osborn, type, Am. Mus. 674.
“ “ “ “	“ “	7.	*M. obliquidens* Osborn, type, Am. Mus. 668.
“ “ “ “	“ “	8.	*M. eulophus* Osborn, type, Am. Mus. 8791.

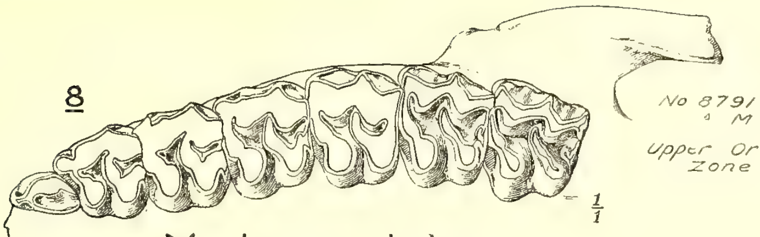
Right column.

Western Nebraska?	Lower “	9.	*M. celer* Marsh, holotype, Yale Mus. 11302.
Cypress Hills, Assiniboia, Can.	“ “	10.	*M. westoni* Cope, type, Ottawa Mus. 6289.
Cheyenne River, So. Dak.		11.	*M.* ? var., referred specimen, Am. Mus. 9326, *indet.**
“ “ “ “		12.	*M.* ? sp. referred specimen, Mus. Comp. Zool. 6547.
? ? ? ?		13.	*M. bairdii*, specimen and record *indet.* (Composite drawing from different individuals).

Dental characters of the *Mesohippus* stage are observed in the evolution from *Mesohippus montanensis* of the Lower Titanotherium zone through seven specific stages of ascending mutations to *Mesohippus eulophus* of the Upper Oreodon zone. Note the gradual evolution of the hypostyle as a bud from the posterior cingulum, attaining a permanent triangular form in *M. trigonostylus* of the Metamynodon sandstones, which are channel deposits contemporary with the Lower Oreodon clays. Thus the *M. bairdii* stage and *M. trigonostylus* stage are believed to be nearly contemporaneous.

* This progressive molar series is recorded from the Upper Oreodon zone of Pawnee Buttes; the correlation is somewhat uncertain.

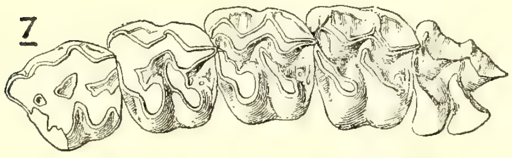
8



No 8791 Type
A M
Upper Oreodon
Zone

Mesohippus eulophus

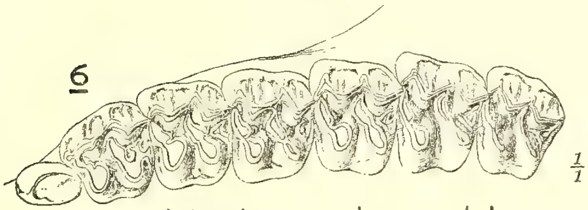
7



No. 668 Type
A M
Middle Oreodon
Zone

Mesohippus obliquidens

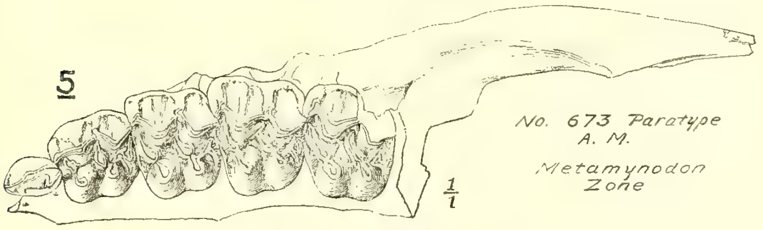
6



No. 674 Type
A. M
Metamynodon
Zone

Mesohippus trigonostylus

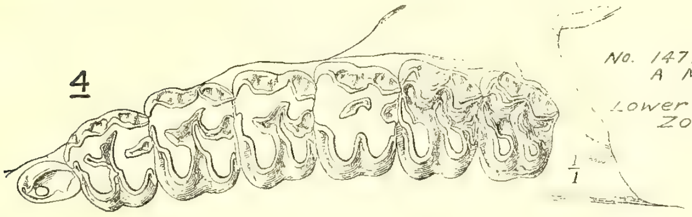
5



No. 673 Paratype
A. M.
Metamynodon
Zone

Mesohippus trigonostylus

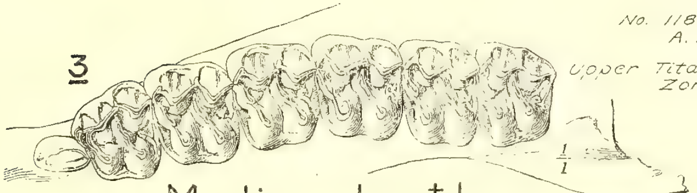
4



No. 1477 Neotype
A M
Lower Oreodon
Zone

Mesohippus bairdii

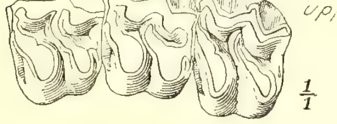
3



No. 1180 Type
A. M.
Upper Titanotherium
Zone

Mesohippus hypostylus

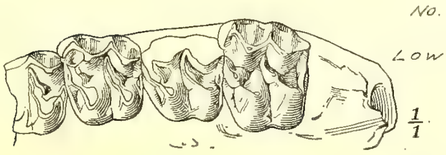
2



No 514a Type (rev.)
A. M.
Upper Titanotherium
Zone

Mesohippus proteulophus

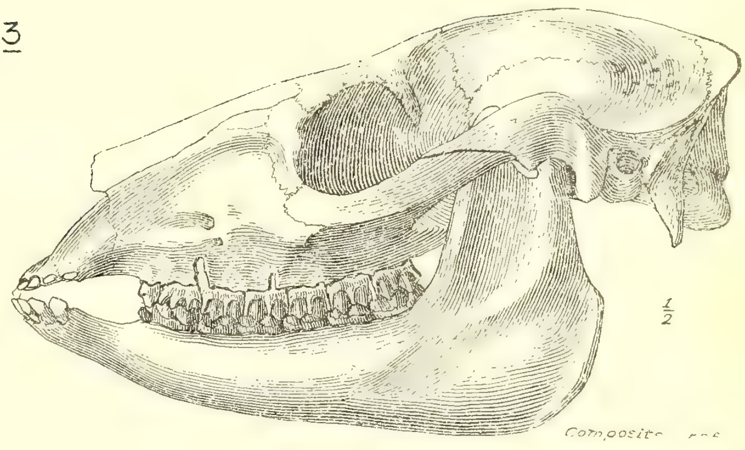
1



No. 9662 Type (rev.)
A M.
Lower Titanotherium
Zone

Mesohippus montanensis

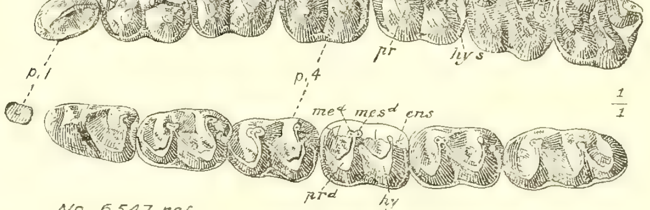
13



Composite ref.

Mesohippus bairdii

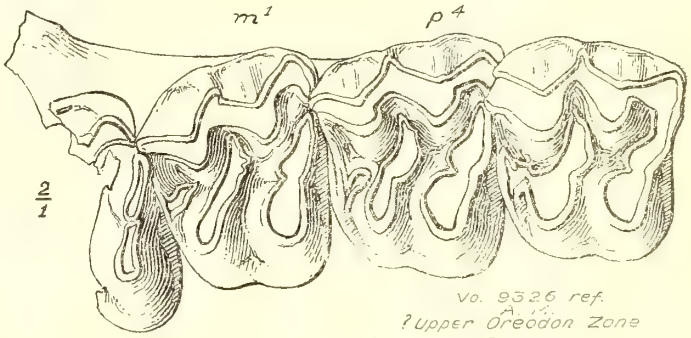
12



No. 6547 ref.
Horv. Mus. Comp. Zool.

Mesohippus ? spec.

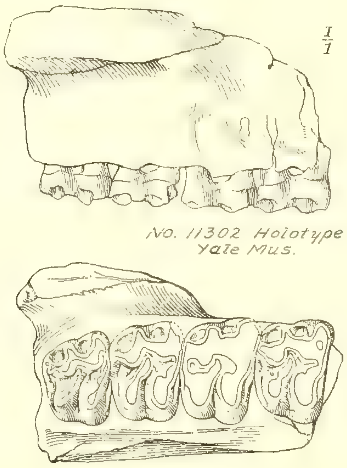
11



Vo. 9326 ref.
A. M.
?Upper Oreodon Zone

Mesohippus ?var.

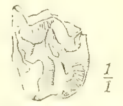
9



No. 11302 Holotype
Yale Mus.

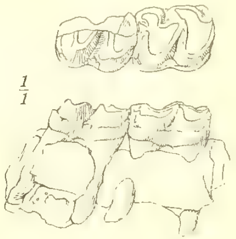
Mesohippus celer

10



No. [illegible] Type
Ottawa Mus

Mesohippus westoni



No. 6313 Cotype
Ottawa Mus

PLATE 3.

UPPER TEETH, *MIOHIPPUS.*

PLATE 3.

UPPER TEETH OF *MIOHIPPUS* FROM SOUTH DAKOTA AND OREGON.

All figures natural size.

Left column.

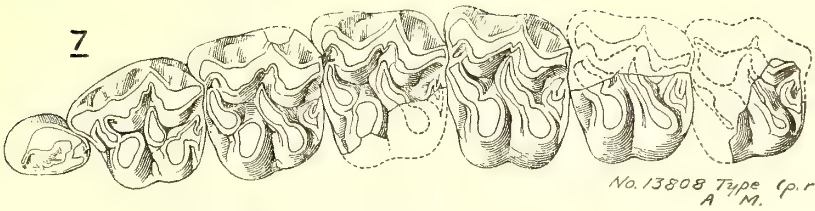
Cheyenne River, So. Dak.	Upper Oligocene	1.	*Miohippus meteulophus* Osborn, type, Am. Mus. 1210 (partly reversed in drawing).
“ “ “ “	“ “	2.	*M. brachystylus* Osborn, type, Am. Mus. 11860.
“ “ “ “	“ “	3.	*M. intermedius* Osborn and Wortman, type, Am. Mus. 1196.
“ “ “ “	“ “	4.	*M. gidleyi* Osborn, type, Am. Mus. 1192.
“ “ “ “	“ “	5.	*M. validus* Osborn, type, Am. Mus. 1218 (partly reversed in drawing).
Lower Rosebud, So. Dak.	Lower Miocene	6.	*M. equinanus* Osborn, type, Am. Mus. 12912.
“ “ “ “	“ “	7.	*M. gemmarosæ*, type, Am. Mus. 13808 (partly reversed in drawing).

Right column.

Middle John Day, Ore.	Upper Oligocene	8.	*M. quartus* Osborn, type, Am. Mus. 7267.
“ “ “ “	“ “	9.	*M. brachylophus* Cope, referred specimen, Am. Mus. 7262.
“ “ “ “	“ “	10.	*M. equiceps* Cope, type, Am. Mus. 7261.
“ “ “ “	“ “	13.	*M. primus* Osborn, type, Am. Mus. 7291 (reversed in drawing).
“ “ “ “	“ “	14.	*M. annectens* Marsh, cotype or referred specimen, Yale Mus. 12230.
John Day River, Ore.	Lower Miocene	12.	*M. condoni* Leidy, type, Acad. Nat. Sci. Phila. (drawn from Leidy's figure).
Cheyenne River, So. Dak.	Upper Oligocene	11.	*M. crassicuspis* Osborn, type, Am. Mus. 683 (reversed in drawing).
John Day River, Ore.	Lower Miocene	15.	*M. annectens* Marsh, type, Yale Mus. 11275.

The upper teeth included within the *Miohippus* stage extend from the species *M. meteulophus* of the Leptauchenia zone to those of *M. gemmarosæ* of the Promerycochœrus zone of the Lower Rosebud. They are distinguished by variations in size, by varying degrees of development of the hypostyle, which is rudimentary in *M. meteulophus*, an elongate loop in *M. brachystylus*, a triangular fold in *M. intermedius*, *M. validus*, and *M. gemmarosæ*, and by the progressive development of the protoconule and metaconule.

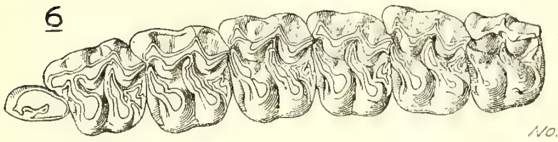
7



No. 13808 Type (p. rev)
A. M.
Promerycochoerus Zone

Miohippus gemmarosae

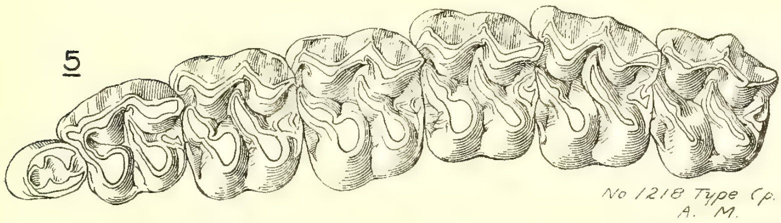
6



No. 12912 Type
A. M.
Promerycochoerus Zone

Miohippus equinanus

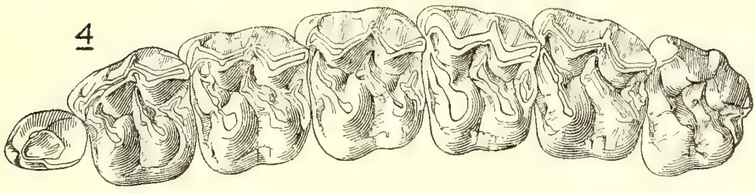
5



No 1218 Type (p. rev)
A. M.
Protoceras Zone

Miohippus validus

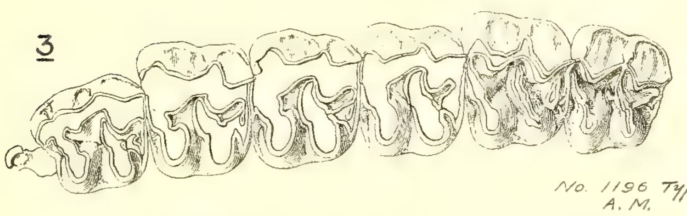
4



No. 1192 Type
A. M.
Protoceras Zone

Miohippus gidleyi

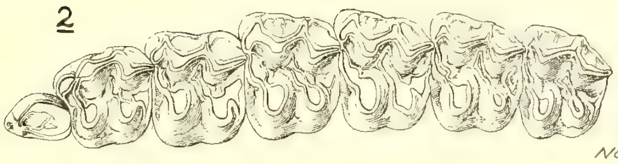
3



No. 1196 Type
A. M.
Protoceras Zone

Miohippus intermedius

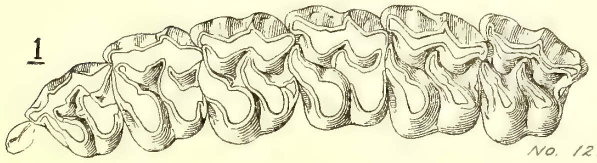
2



No. 11860 Type
A. M.
Leptauchenia Zone

Miohippus brachystylus

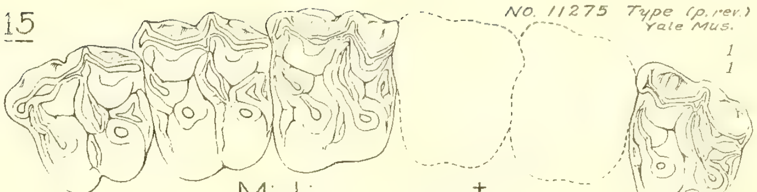
1



No. 1210 Type (p. rev
A. M.
Leptauchenia Zone

Miohippus meteulophus

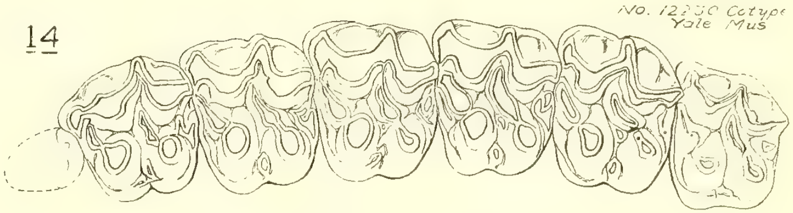
15



No. 11275 Type (p. rev.)
Yale Mus.

Miohippus annectens

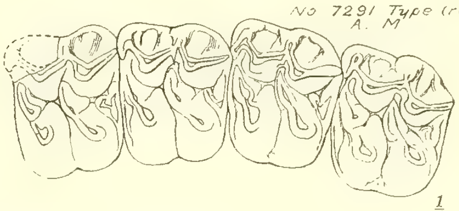
14



No. 12230 Cotype
Yale Mus

Miohippus annectens

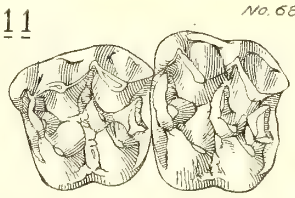
13



No 7291 Type (rev)
A. M

Miohippus primus

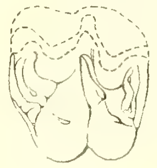
11



No. 683 Type (rev.)
A. M.

Miohippus crassicuspis

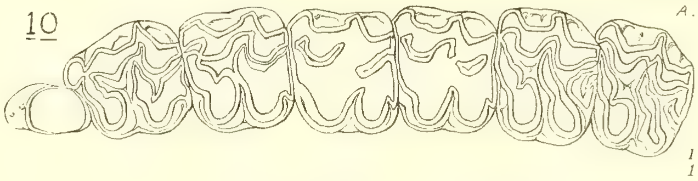
12



After Leidy, Type
Phila. Acad.

Miohippus condoni

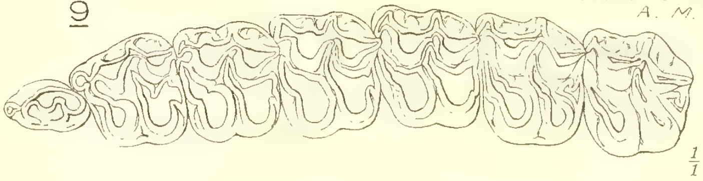
10



No 7261 Type
A. M

Miohippus equiceps

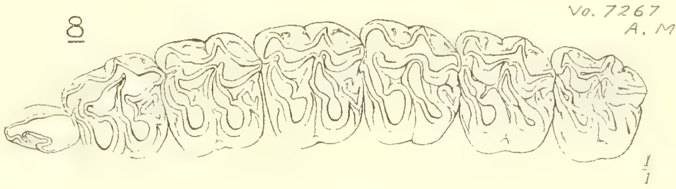
9



No 7262 ref
A. M.

Miohippus brachylophus

8



No. 7267 Type
A. M.

L.M.S.

Miohippus quartus

PLATE 4.

UPPER AND LOWER TEETH, *MIOHIPPUS*.

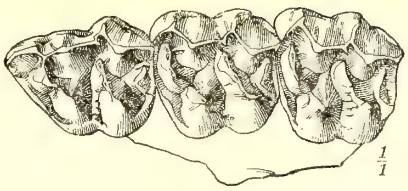
PLATE 4.

UPPER AND LOWER TEETH OF *MIOHIPPUS* FROM SOUTH DAKOTA AND OREGON.

Teeth natural size. Skulls and jaws one-half natural size.

			Left column.
Pine Ridge, So. Dak.	Lower Miocene	1.	*Miohippus gemmarosæ*, Osborn, paratype, Am. Mus. 12928.
" " " "	" "	2.	*M. gemmarosæ* Osborn, paratype, Am. Mus. 13809.
" " " "	" "	3.	*M. gemmarosæ* Osborn, paratype, 12917c.
" " " "	" "	4.	*M. gemmarosæ* Osborn, paratype, 12917a.
			Right column.
John Day River, Ore.	" "	5.	*M. primus* Osborn, type, Am. Mus. 7291 (partly reversed in drawing).
" " " "	" "	6.	*M. quartus* Osborn, paratype, Am. Mus. 7285 (partly reversed in drawing).
" " " "	" "	7.	*M. acutidens* Sinclair, type, Univ. Cal. Pal. Col. 376.
" " " "	Upper "	8.	*M. quartus* Osborn, type, Am. Mus. 7267 (reconstructed in drawing).
Pine Ridge, So. Dak.	Lower "	9.	*M. gemmarosæ* Osborn, type, Am. Mus. 13808.

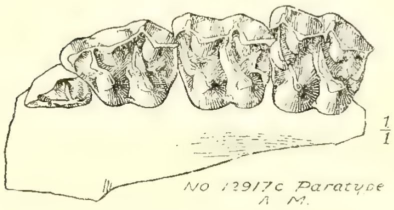
4



No. 12917a Paratype A. M.

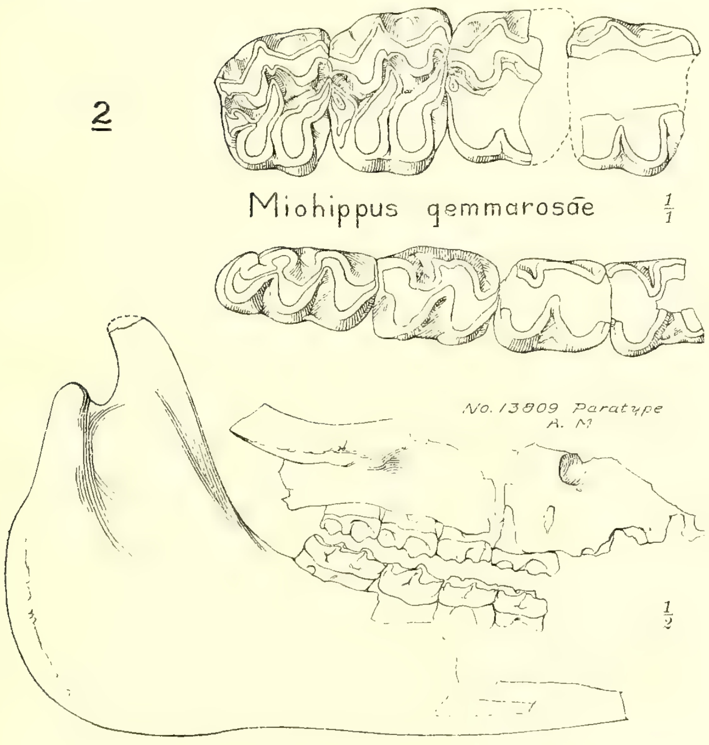
Miohippus gemmarosæ

3



No. 12917c Paratype A. M.

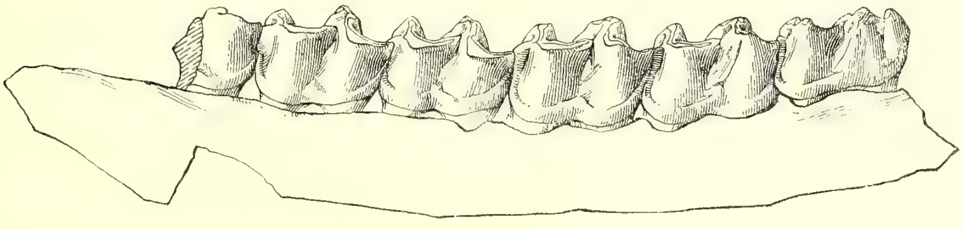
2



Miohippus gemmarosæ 1/1

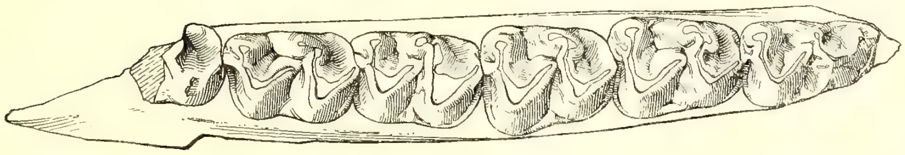
No. 13809 Paratype A. M

1/2



Miohippus gemmarosæ 1/1

1



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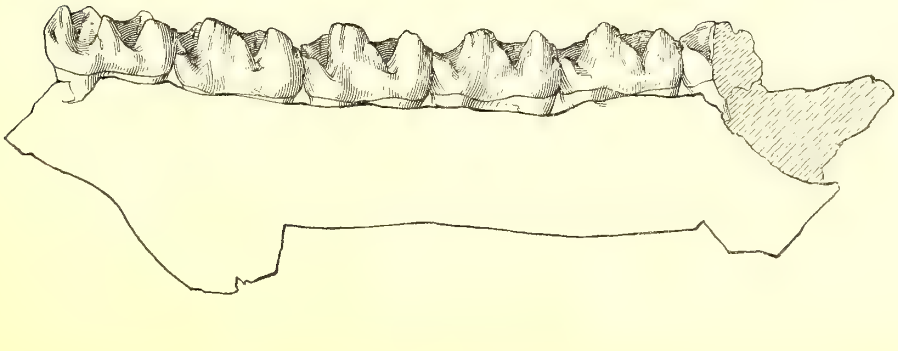
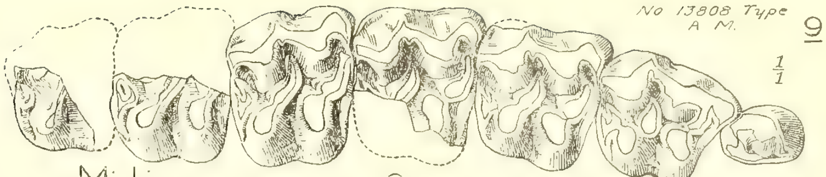


L. M. S.



No 13808 Type A. M.

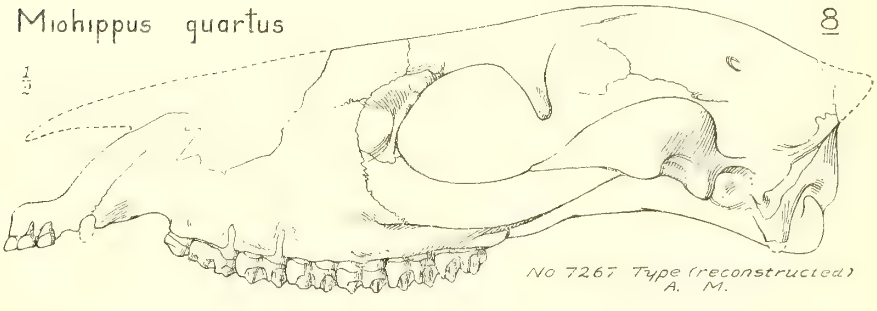
9

1/1

Miohippus gemmarosæ

Miohippus quartus

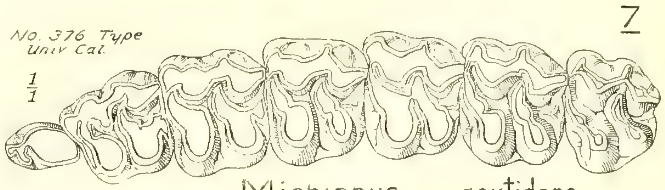
8



No 7267 Type (reconstructed) A. M.

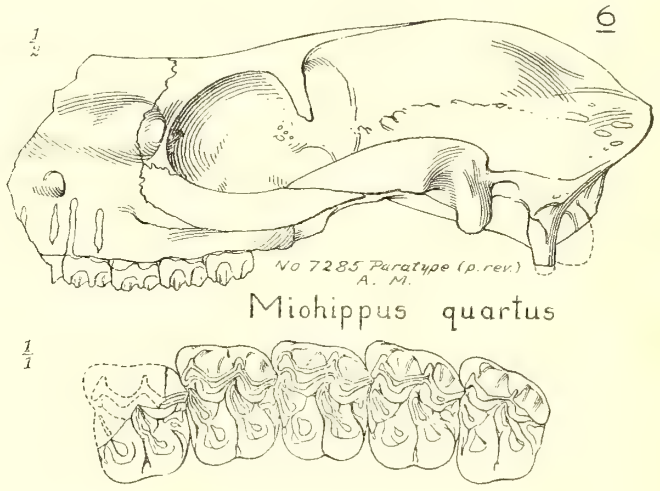
7

No. 376 Type Univ Cal.



Miohippus acutidens

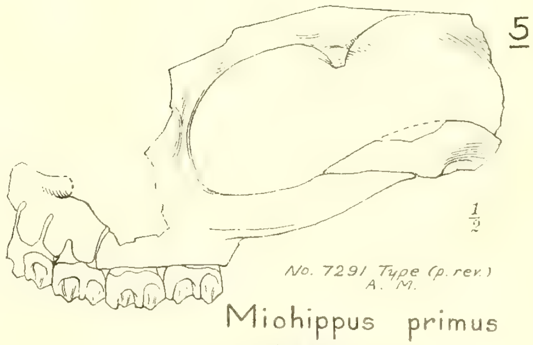
6



No 7285 Paratype (p. rev.) A. M.

Miohippus quartus

5



No. 7291 Type (p. rev.) A. M.

Miohippus primus

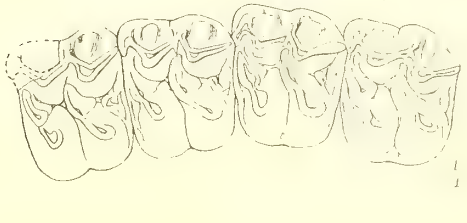


PLATE 5.

TEETH, FEET, *MIOHIPPUS*, *HYPOHIPPUS*.

PLATE 5.

TEETH AND FEET OF *MIOHIPPUS, KALOBATIPPUS, ANCHITHERIUM, HYPOHIPPUS.*

COMPARISON OF THE TEETH AND FEET OF THE OLIGOCENE AND MIOCENE ANCHITHERES.

All figures natural size, except 12 and 13 which are one-half natural size.

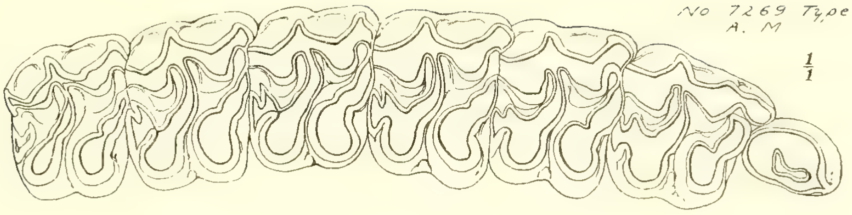
Figs. 1–9. Last lower molar of *Miohippus sp. div., Kalobatippus, Anchitherium,* and *Hypohippus,* showing the reduced third lobe, or hypoconid, in the two latter genera.

Figs. 10–11. Upper teeth of *Kalobatippus* Osborn and of *Anchitherium,* showing the reduction of m^3 and closing of the postfossette in *Anchitherium,* greater antero-posterior elongation of the teeth, and more perfected lophodonty.

Figs. 12–13. Metatarsals of *Kalobatippus* Osborn and of *Anchitherium,* showing the relative slenderness of the former but with unreduced lateral digits.

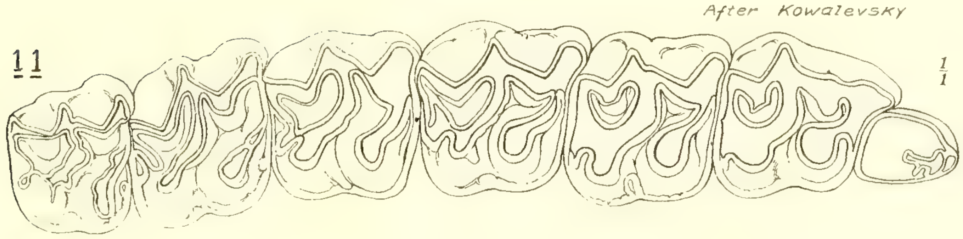
John Day, Ore.	Upper Oligocene	1.	*Miohippus longicristis* Cope, Am. Mus. 7268, referred specimen.
Middle John Day, Ore.	“ “	2.	*M. quartus* Osborn, Amer. Mus. 7293, referred specimen (reversed in drawing).
“ “ “ “	“ “	3.	*M. brachylophus* Cope, Am. Mus. 7281, referred specimen.
“ “ “ “	“ “	4.	*M. equiceps* Cope, Am. Mus. 7287, referred specimen, unworn molar (reversed in drawing).
“ “ “ “	“ “	5.	*M. equiceps* Cope, type, Am. Mus. 7261, partly worn molars.
Upper John Day, Ore.	Lower Miocene	6.	*Kalobatippus præstans* Cope, type, Am. Mus. No. 7269.
Lower Harrison, Agate, Nebr.	“ “	7.	*K. agatensis,* type, Am. Mus. 14211 (reversed in drawing).
Georgensgmund, Bavaria.	Middle Miocene	8.	*Anchitherium aurelianense,* Am. Mus. 10746, referred specimen (reversed in drawing).
Pawnee Creek, Col.	“ “	9.	*Hypohippus osborni* Gidley, type, Am. Mus. 9407.
Upper John Day, Ore.	Upper Oligocene	10.	*Kalobatippus præstans* Cope, type, Am. Mus. 7269.
Sansan, France.	Middle Miocene	11.	*Anchitherium aurelianense* Cuv. (drawn from Kowalevsky's figure).
Upper John Day, Ore.	Upper Oligocene	12.	*Kalobatippus præstans* Cope, type, Am. Mus. 7269.
Sansan, France.	Middle Miocene	13.	*Anchitherium aurelianense* (drawn from Kowalevsky's figure).

10



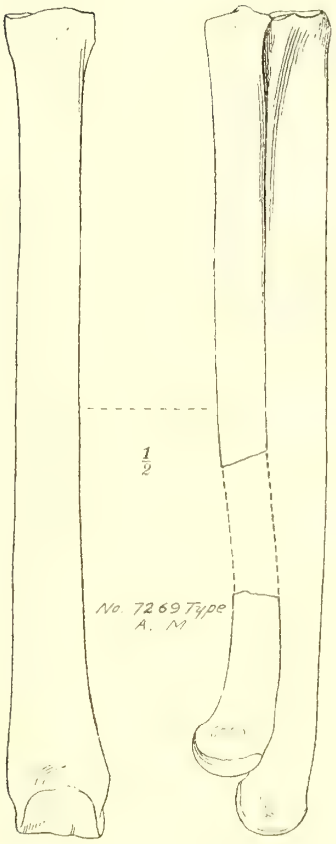
Kalobatippus prǣstans

11



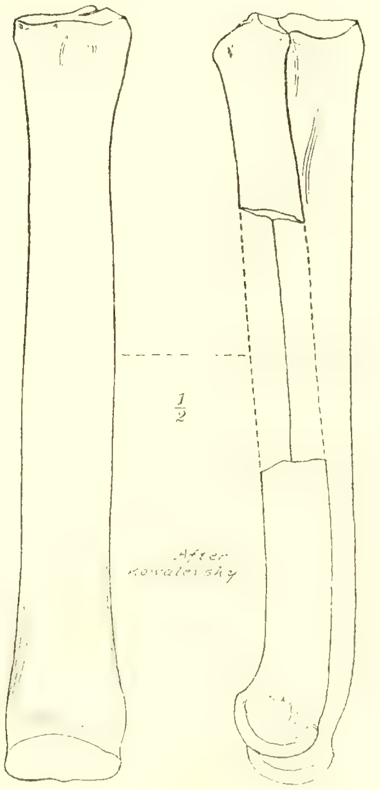
Anchitherium aurelianense

12



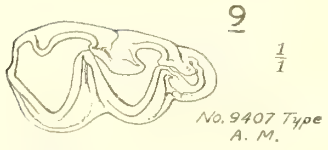
Kalobatippus prǣstans

13



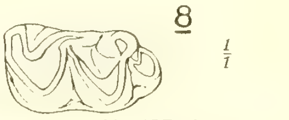
Anchitherium aurelianense

9



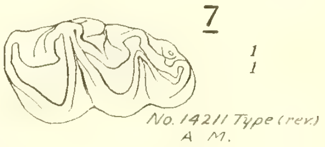
Hypohippus osborni

8



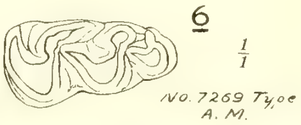
Anchitherium aurelianense

7



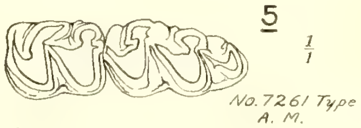
Kalobatippus agatensis

6



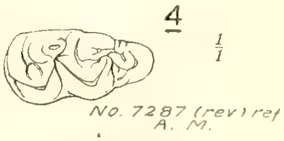
Kalobatippus prǣstans

5



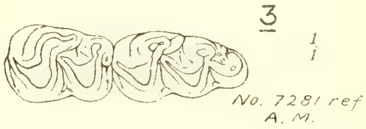
Miohippus equiceps

4



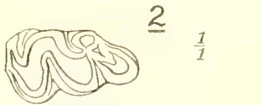
Miohippus equiceps

3



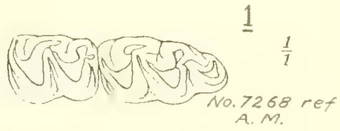
Miohippus brachylophus

2



Miohippus quartus

1



Miohippus longicristis

L. M. S.

PLATE 6.

FACE, *MIOHIPPUS*, *ARCHÆOHIPPUS*, ETC.

PLATE 6.

PREORBITAL FOSSÆ IN OLIGOCENE AND MIOCENE EQUIDÆ FROM OREGON, COLORADO, SOUTH DAKOTA AND NEBRASKA.

(Left column) Comparison of front of skull in *Miohippus, Archæohippus, Kalobatippus,* and *Hypohippus.*

(Right column) Comparison of front of skull in species of *Parahippus* and *Merychippus.* The lachrymal fossa is broad and comparatively shallow in the later species. The malar fossa is not differentiated.

All figures one-half natural size.

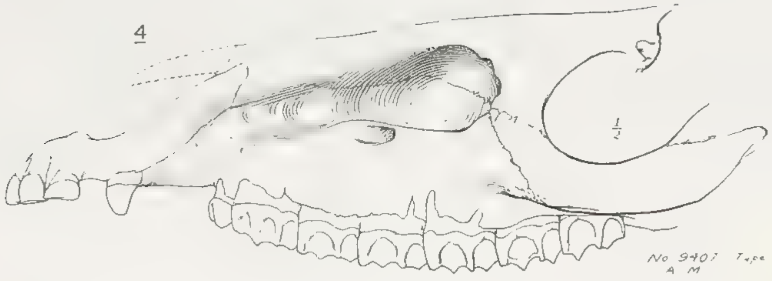
Left column.

Middle John Day, Ore.	Upper Oligocene	1. *Miohippus equiceps,* type, Am. Mus. 7261. Lachrymal fossa broad, shallow; malar fossa not differentiated.
Mascall, Ore.	Middle Miocene	2. *Archæohippus ultimus* Cope, type, Am. Mus. 8174. Lachrymal and malar fossæ deep, well differentiated.
Upper John Day, Ore.	Uppermost Oligocene, transitional to Lower Miocene	3. *Kalobatippus præstans* Cope, type, Am. Mus. 7269. Lachrymal fossa broad, rather shallow; malar fossa not differentiated.
Pawnee Creek, Col.	Middle Miocene	4. *Hypohippus osborni* Gidley, type, Am. Mus. 9407. Lachrymal fossa deep, contracted; no malar fossa.

Right column.

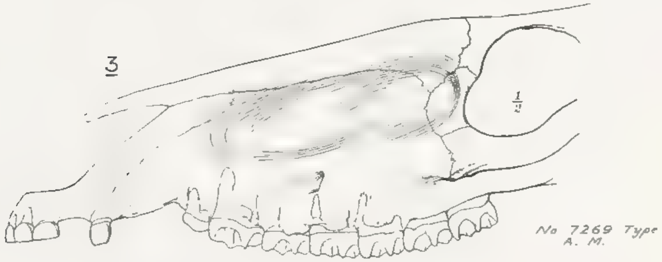
Lower Rosebud, Pine Ridge, So. Dak.	Lower Miocene	5. *Parahippus pristinus* Osborn, type, Am. Mus. 12918.
Upper Harrison, Sioux Co., Nebr.	" "	6. *P. nebrascensis primus* Osborn, type, Am. Mus. 13770.
Sheep Creek, Sioux Co., Nebr.	Middle "	7. *P. avus* Marsh, referred specimen, Am. Mus. 14182 (reversed in drawing).
Mascall, Ore.	" "	8. *Merychippus isonesus* Cope, type, Am. Mus. 8175.

4



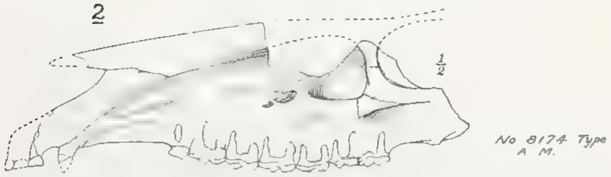
Hypohippus osborni

3



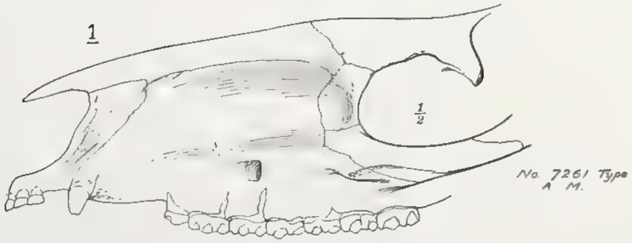
Kalobatippus praestans

2



Archaeohippus ultimus

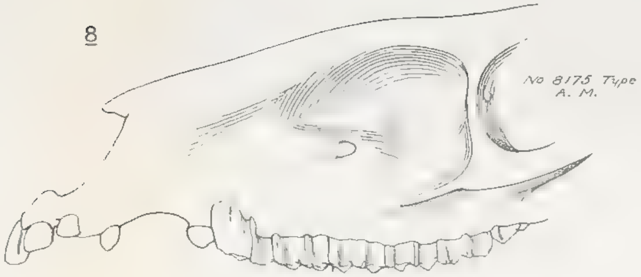
1



Miohippus equiceps

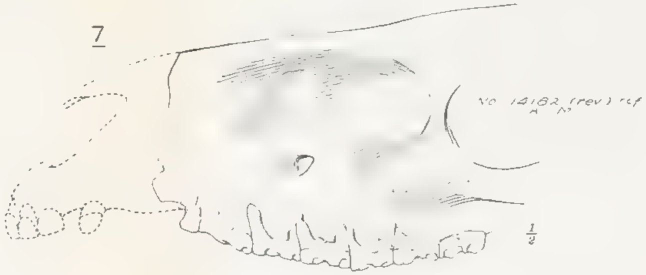
L.M.S.

8



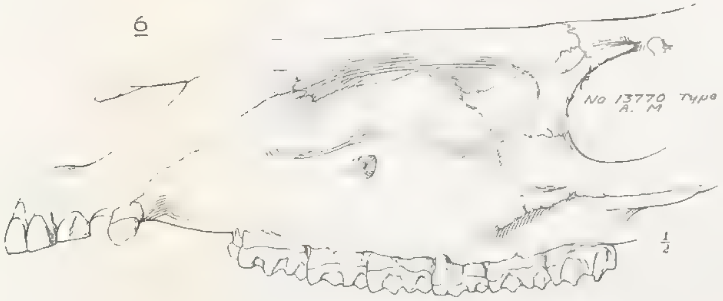
Merychippus isonesus

7



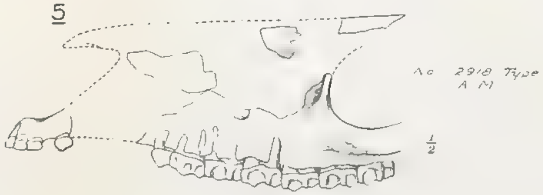
Parahippus avus

6



Parahippus nebrascensis primus

5



Parahippus pristinus

PLATE 7.

SKULL, *PARAHIPPUS.*

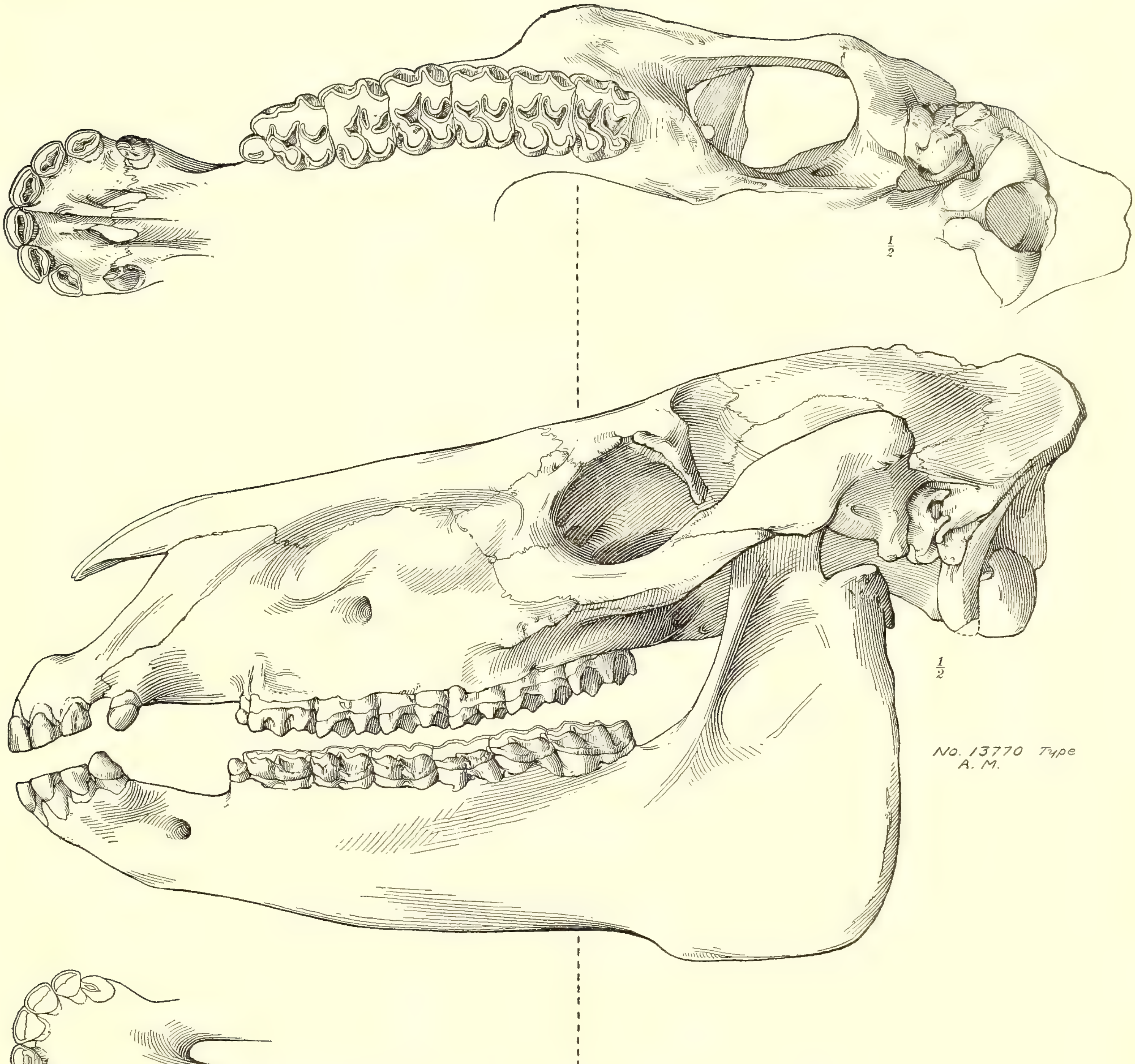
PLATE 7.

TYPE SKULL AND LOWER JAWS OF *PARAHIPPUS NEBRASCENSIS PRIMUS* OSBORN.

All figures one-half natural size.

Amer. Mus. 13770, type. This skull belongs to a fully adult male and consequently shows very clearly the distinctive characters of the *Parahippus* skull stage. The crochet is well developed on the superior molar teeth. The hypostyle is simple and does not show the progressive hypostyle fold, the pli hypostyle.

This male skull, which was found in the Lower Miocene of the Upper Harrison near Agate, Nebraska, is more progressive than the type skull of *P. nebrascensis* Peterson, which belongs to a female. In this male skull the facial region is relatively longer.



Parahippus nebrascensis primus

PLATE 8.

UPPER AND LOWER TEETH, *PARAHIPPUS.*

PLATE 8.

UPPER AND LOWER TEETH OF *PARAHIPPUS* FROM THE MIOCENE AND LOWER PLIOCENE.

COMPARISON OF MOLAR-PREMOLAR SERIES IN DIFFERENT MIOCENE SPECIES.

All figures natural size.

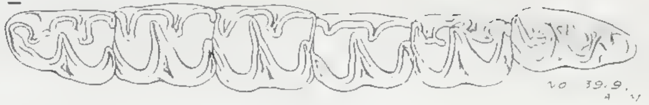
Left column.

Upper Rosebud, S. D.	Lower Miocene	1.	*Parahippus coloradensis præcurrens* Osborn, paratype, Amer. Mus. 12925.
Near Agate, Nebraska	" "	2.	*P. nebrascensis primus* Osborn, type, Am. Mus. 13770.
Upper Rosebud, S. D.	Lower Miocene	3.	*P. texanus* Leidy, referred specimen, Am. Mus. 12924.
Deep River, Mont.	Middle "	4.	*P. crenidens* Scott, type, Princeton Mus. 10430 (drawing from cast, Am. Mus. 10782).
Pawnee Creek, Col.	" "	5.	*P. pawniensis* Gidley, type, Am. Mus. 9085 (reversed in drawing).
Sheep Creek, Nebr.	" "	6.	*P. avus* Marsh, referred specimen, Am. Mus. 14182.
Pawnee Creek, Col.	" "	7.	*P. coloradensis* Gidley, paratype, Am. Mus. 9412.
Sioux Co., Nebr.	?Lower Pliocene	8.	*P. cognatus* Leidy, referred specimens, Am. Mus. 13919, 13943.

Right column.

John Day River, Ore.	Middle Miocene	9.	*Parahippus avus* Marsh, type, Yale Mus. 11281, lower teeth and jaw fragment containing p_2–m_2 of the right side.
" " " "	" "	10.	*P. avus* Marsh, type, Yale Mus. 11281 (m^1 reversed in drawing).
Cottonwood Creek, Ore.	" "	11.	*P. brevidens* Marsh, type, Yale Mus. 11274, two unworn molars, m^{2-3} of the left side.
Pawnee Creek, Col.	" "	12.	*P. coloradensis* Gidley, type, Amer. Mus. 9040, an unworn m^3 of the left side, and a worn molar, ?m^1, of the right side.

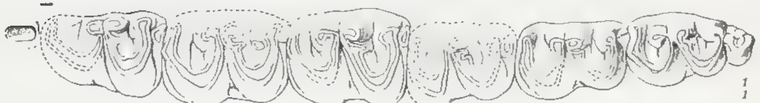
8



No 39.9, 3423 ref
A M

Parahippus cognatus

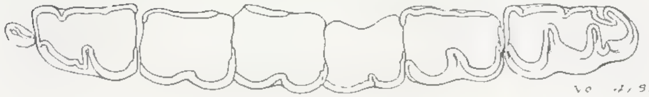
7



No 9412 Paratype
A M

Parahippus coloradensis

6



No 4192 ref
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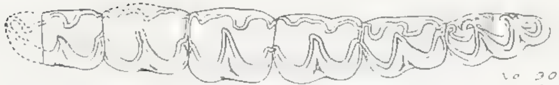
Parahippus avus

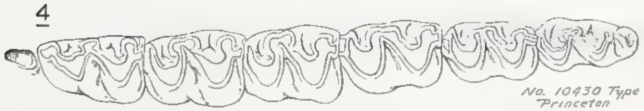
5



No 3085 Type revi
A M

Parahippus pawniensis

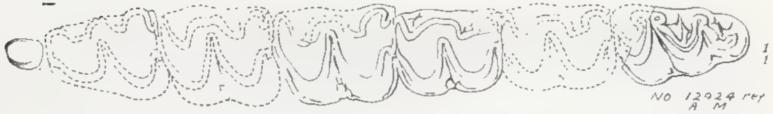
4



No. 10430 Type (Drawn from cast)
Princeton

Parahippus crenidens

3



No 12924 ref
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Parahippus texanus

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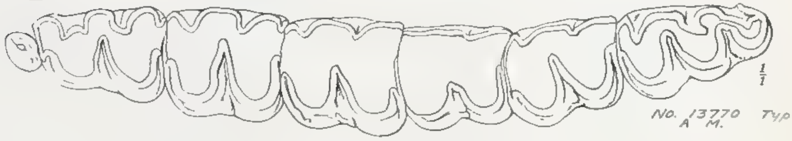
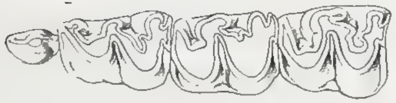


No. 13770 Type
A M.

Parahippus nebrascensis primus

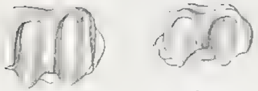
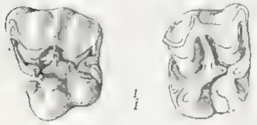
1



No 12925 Paratype
A M

L.M.S.

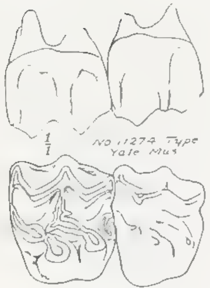
Parahippus coloradensis praecurrens

Parahippus coloradensis 12

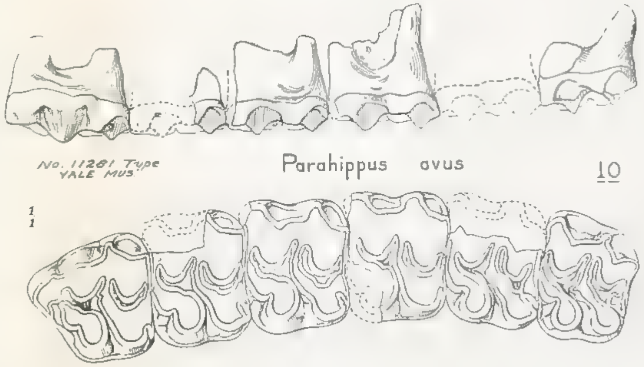
No 9040 Type
A. M

11



No 11274 Type
Yale Mus

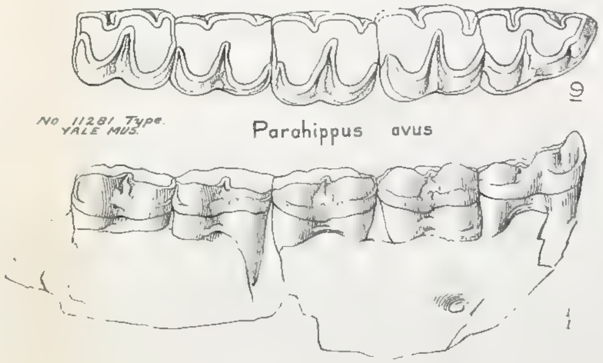
Parahippus brevidens



No. 11281 Type
YALE MUS.

Parahippus avus

10



9

No. 11281 Type.
YALE MUS.

Parahippus avus

PLATE 9.

UPPER AND LOWER TEETH, *PARAHIPPUS.*

PLATE 9.

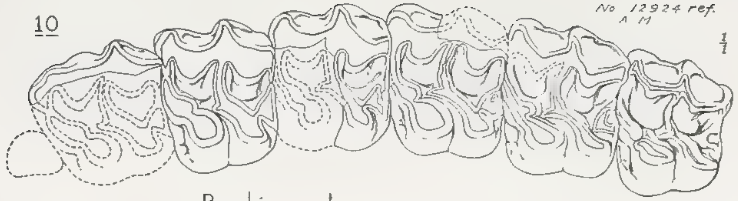
UPPER AND LOWER TEETH OF *PARAHIPPUS* FROM THE LOWER AND MIDDLE MIOCENE.

All figures natural size.

These are all primitive species not far removed from *Miohippus* of the Upper Oligocene, especially *P. pristinus* Osborn of the transition beds. In *P. pristinus* Osborn observe the extraordinary position of the pli prefossette, similar to that in *Miohippus gidleyi* Osborn and different from that in *P. coloradensis præcurrens* Osborn, etc.

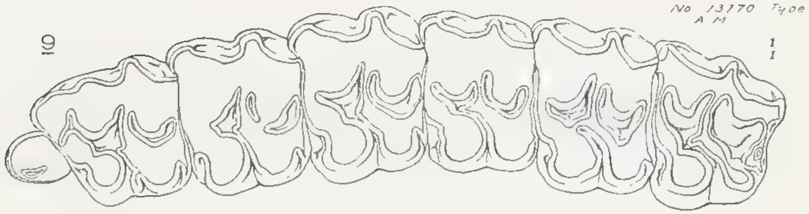
		Left column.
Agate, Sioux Co., Nebr.	Lower Miocene	6. *P. tyleri* Loomis, referred specimen, Am. Mus. 13769, lower teeth.
Pine Ridge, So. Dak.	“ “	7. *Parahippus pristinus* Osborn, type, Am. Mus. 12918.
Near Agate, Sioux Co., Nebr.	“ “	8. *P. tyleri* Loomis, referred specimen, Am. Mus. 13769, upper teeth.
“ “ “ “ “	“ “	9. *P. nebrascensis primus* Osborn, type, Am. Mus. 13770.
Pine Ridge, So. Dak.	“ “	10. *P. texanus* Leidy, referred specimen, Am. Mus. 12924.
		Right column.
Pine Ridge, So. Dak.	“ “	1. *Parahippus coloradensis præcurrens* Osborn type, Am. Mus. 13018.
Deep River, Mont.	Middle “	2. *P. crenidens* Scott, type, Princeton Mus. 10430 (reversed in drawing).
Pawnee Creek, Col.	“ “	3. *P. pawniensis* Gidley, type, Am. Mus. 9085 (reversed in drawing).
Sioux County, Nebr.	“ “	4. *P. avus* Marsh, referred specimen, Am. Mus. 14182. Tooth much worn.
“ “ “	?Lower Pliocene	5. *P. cognatus* Leidy, referred specimen, Am. Mus. 14322.

10



Parahippus texanus

9



Parahippus nebrascensis primus

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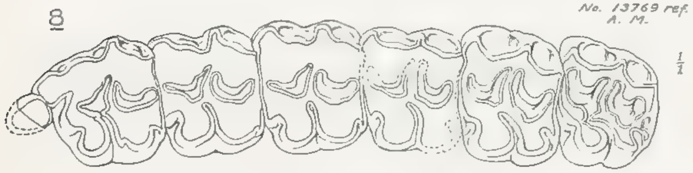
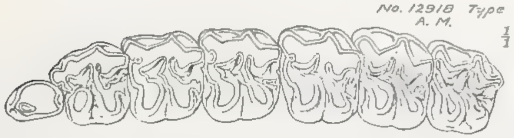


Parahippus tyleri



Parahippus pristinus

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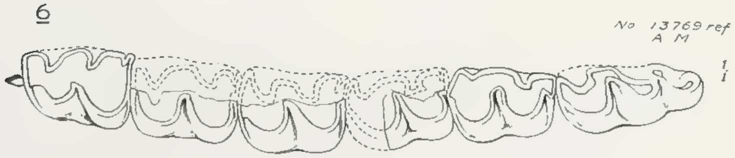
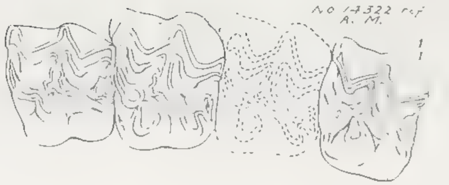


L.M.S.

Parahippus tyleri

5



Parahippus cognatus

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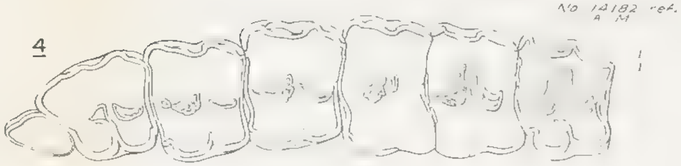
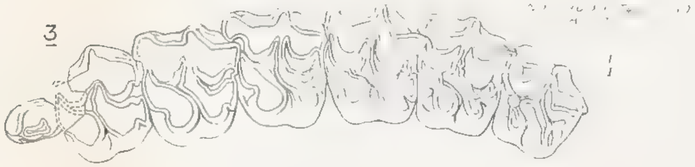


Parahippus avus

3



Parahippus pawniensis

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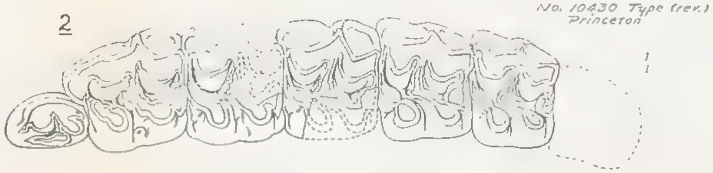

Parahippus crenidens

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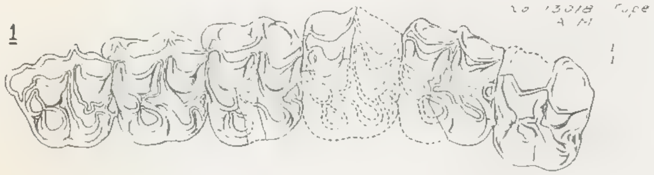


Parahippus coloradensis præcurrens

PLATE 10.

FACE, *MERYCHIPPUS.*

PLATE 10.

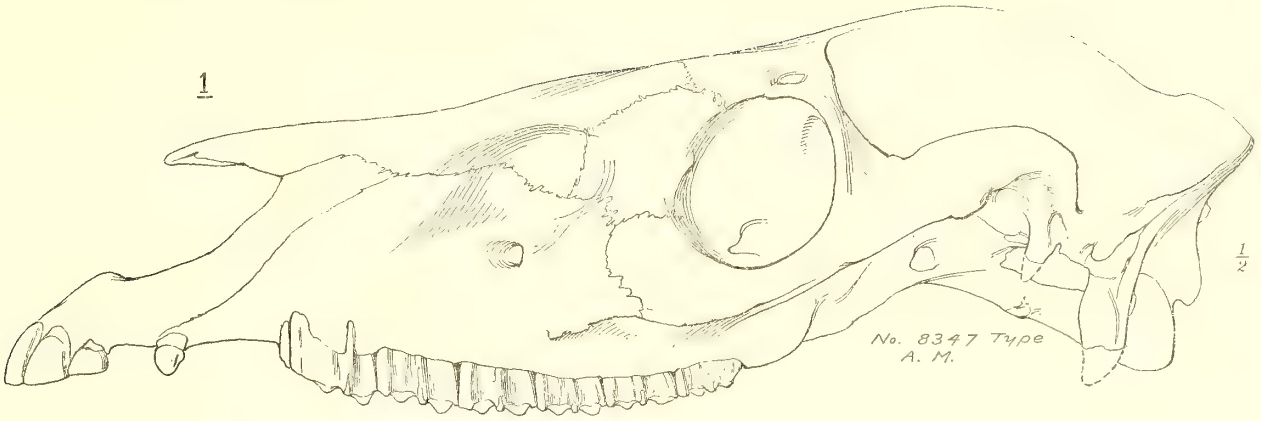
PREORBITAL FOSSÆ IN *MERYCHIPPUS.*

COMPARISON OF SKULLS IN THREE SPECIES.

All figures one-half natural size.

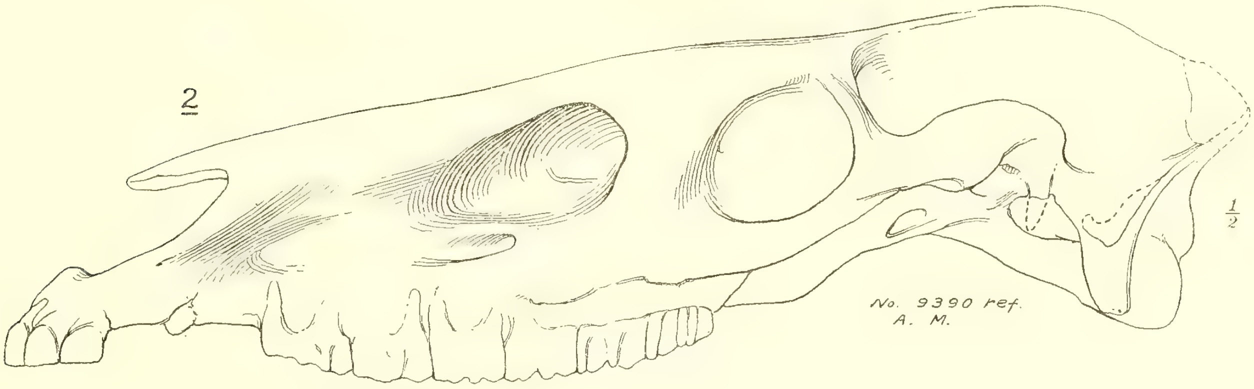
Driftwood Creek, Nebr.	Lower Pliocene	1. *Merychippus republicanus* Osborn, type, Am. Mus. 8347. This is the skull figured by Cope under the name *Hippotherium speciosum* Leidy. Lachrymal fossa shallow, obscure; no malar fossa.
Pawnee Creek, North-eastern Colorado	Middle Miocene	2. *M. sphenodus* Cope, referred specimen, Am. Mus. 9390. Lachrymal fossa deep, constricted; no malar fossa.
Deep River, Mont.	“ “	3. *M. isonesus* var., referred specimen, Am. Mus. 8105. Lachrymal fossa deep, extensive; malar fossa obscurely separated.
Mascall, John Day Basin, Ore.	“ “	4. *M. isonesus* Cope, type, Am. Mus. 8175. Lachrymal fossa deep, extensive; malar fossa obscurely separated.

1



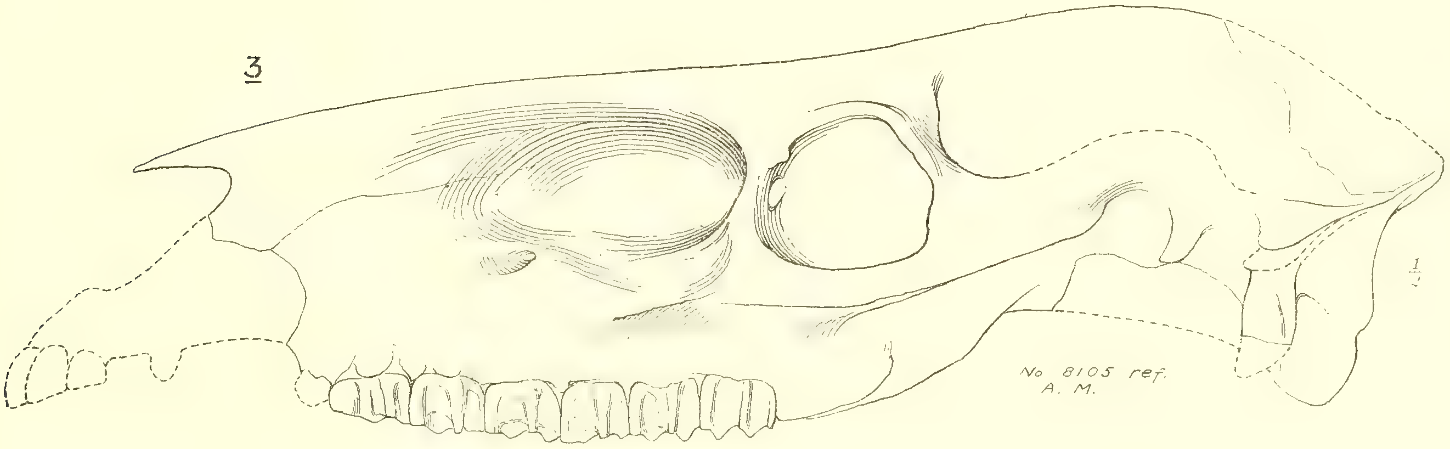
Merychippus republicanus

2



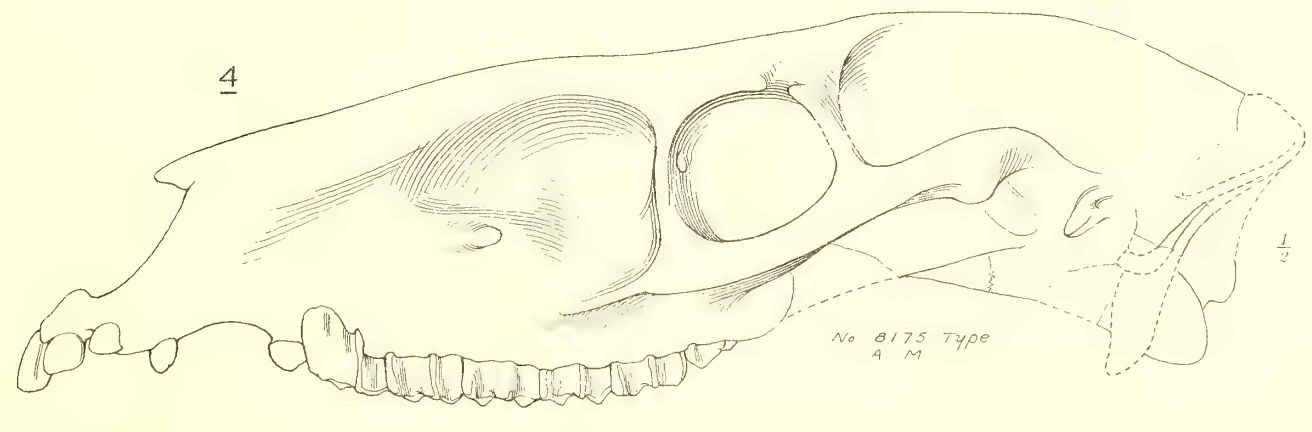
Merychippus sphenodus

3



Merychippus isonesus var.

4



L.M.S.

Merychippus isonesus.

PLATE 11.

FACE OF *MERYCHIPPUS*, OF PROGRESSIVE TYPE.

PLATE 11.

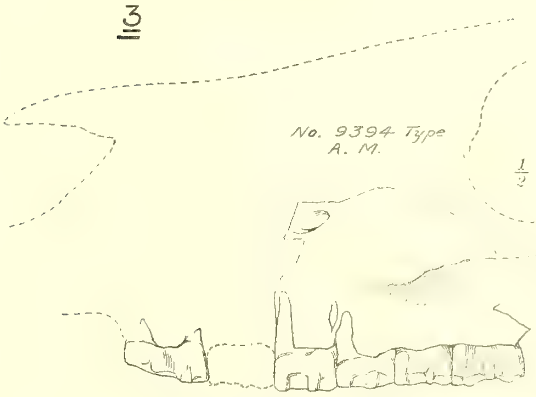
PREORBITAL FOSSÆ IN MERYCHIPPUS.

COMPARISON OF SKULLS IN FOUR SPECIES.

All figures one-half natural size.

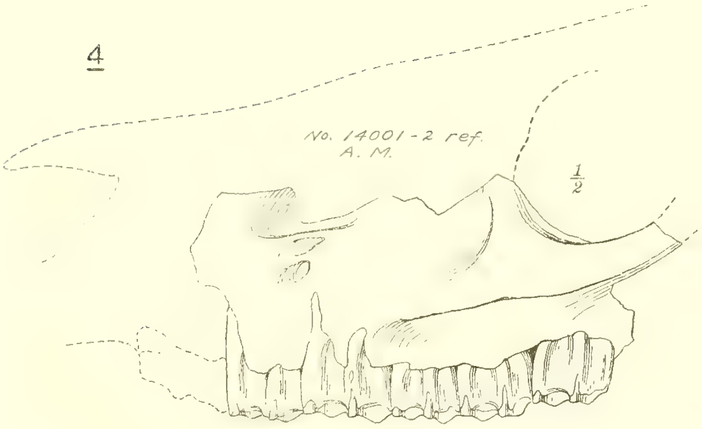
Pawnee Creek, Northeastern Colorado	Middle Miocene	1.	*Merychippus sejunctus* Cope, type, Am. Mus. 8291. Lachrymal and malar fossæ shallow, obscurely separated.
" " " "	" "	2.	*M. paniensis* Cope, referred specimen, Am. Mus. 9382. Lachrymal fossa deep, extensive; malar fossa not differentiated.
" " " "	" "	3.	*M. proparvulus* Osborn, type, Am. Mus. 9394. No malar fossa.
Snake Creek, Sioux County, Nebr.	?Lower Pliocene	4.	*M. calamarius* Cope, referred specimen, Am. Mus. 14001–2. Lachrymal and malar fossæ distinct, well differentiated.

3



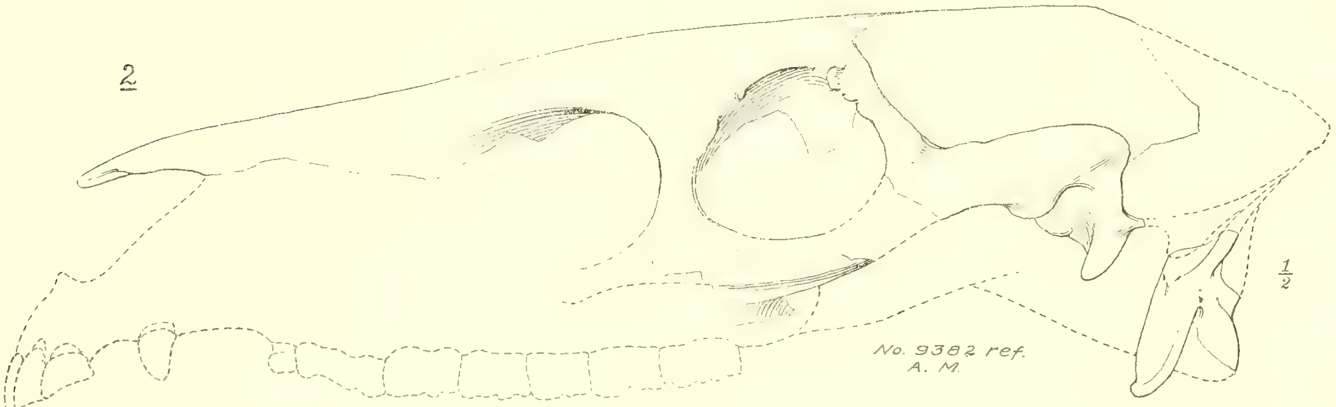
Merychippus proparvulus

4



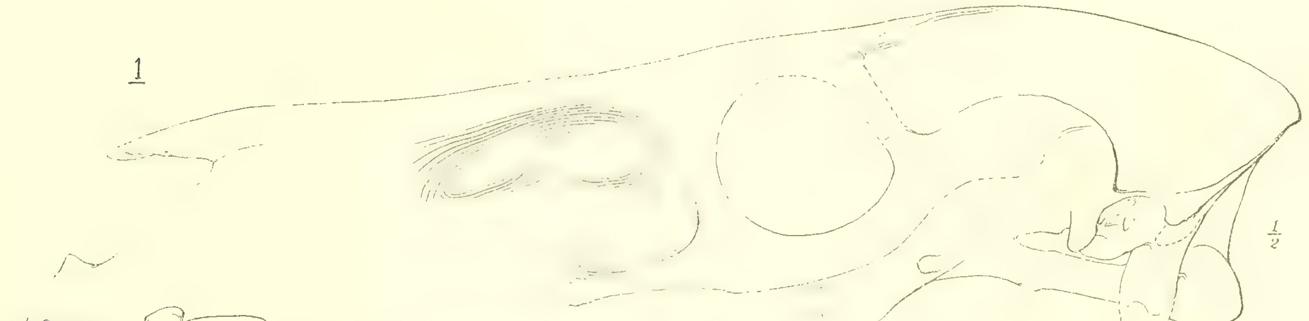
Merychippus calamarius

2



Merychippus paniensis

1



L.M.S.

Merychippus sejunctus

PLATE 12.

SKULL, *MERYCHIPPUS SPHENODUS.*

PLATE 12.

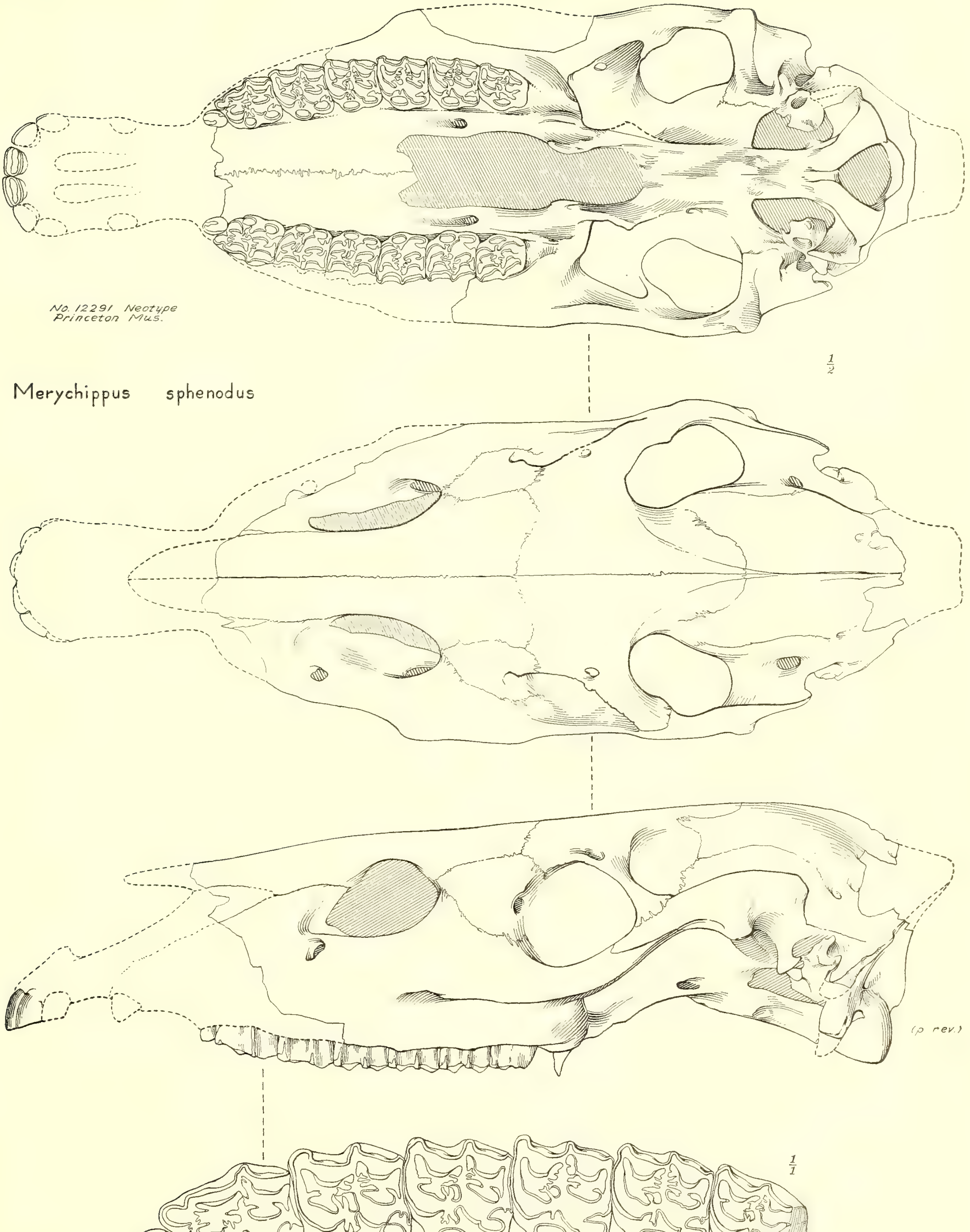
NEOTYPE SKULL OF *MERYCHIPPUS SPHENODUS* COPE.

One-half natural size.

Merychippus sphenodus Cope, neotype, Princeton Mus. 12291 (partly reversed in drawing). This finely preserved skull in the Princeton collection was found by Dr. W. J. Sinclair in Logan County, Colorado, about a mile west of Sand Cañon, in the Middle or Upper Miocene. In the structure of its superior molar teeth it agrees much more closely with the type of *M. sphenodus* than the specimens which Cope selected as the cotype of that species. The molars are distinguished by the duplication of the pli caballin as well as of the pli prefossette and pli postfossette.

The geologic age is almost certainly typical Pawnee Creek. All referred specimens of *M. sphenodus* come from this level (W. D. M. 1918). The type of *M. sphenodus* Cope is recorded as "Pawnee Creek," but the exact locality is not known.

The author is indebted to Dr. W. J. Sinclair for the opportunity of figuring this skull.



Merychippus sphenodus

PLATE 13.

UPPER TEETH, *MERYCHIPPUS.*

PLATE 13.

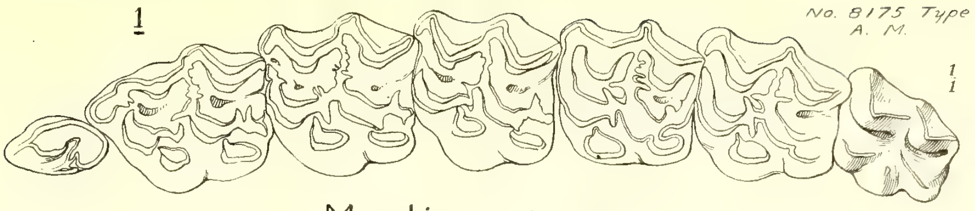
UPPER TEETH OF *MERYCHIPPUS* FROM MONTANA, OREGON, AND NEBRASKA.

COMPARISON OF VARIOUS SPECIES FROM MIDDLE MIOCENE FORMATIONS OF THE WESTERN UNITED STATES.

All figures natural size.

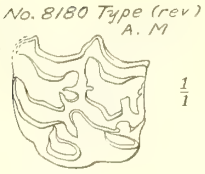
Mascall, Ore.	Middle Miocene	1. *Merychippus isonesus* Cope, type, Am. Mus. 8175.
Deep River, Mont.	“ “	2. *M. isonesus* Cope, referred specimen, Am. Mus. 8105. Upper teeth, much worn.
Sheep Creek, Sioux Co., Nebr.	“ “	3, 3*a*. *M. isonesus primus* Osborn, type, Am. Mus. 14187. Teeth little worn. 3, Crown view, 3*a*, outer view of m^3.
“	“ “	4. *M. isonesus secundus* Osborn, type, Am. Mus. 14179. Teeth less than half worn (partly reversed in drawing).
“	“ “	5, 5*a*. *M. isonesus tertius* Osborn, type, Am. Mus. 14180. Teeth half worn. 5, Crown view, 5*a*, outer view of m^3.
“	“ “	6. *M. isonesus tertius* Osborn, referred specimen, Am. Mus. 14183. Teeth much worn. (Reversed in drawing).
“	“ “	7, 7*a*. *M. isonesus quintus* Osborn, type, Am. Mus. 14185. Teeth little worn. 7, Crown view, 7*a*, outer view of m^3.
Mascall, John Day Basin, Ore.	Middle Miocene	8. *Merychippus seversus* Cope, type, Amer. Mus. 8180. Upper molar, little worn (reversed in drawing).
Mascall (?) “Oregon Desert”	“ “	9. *Merychippus relictus* Cope, type, Amer. Mus. 8673. Upper molar, about half worn.

1



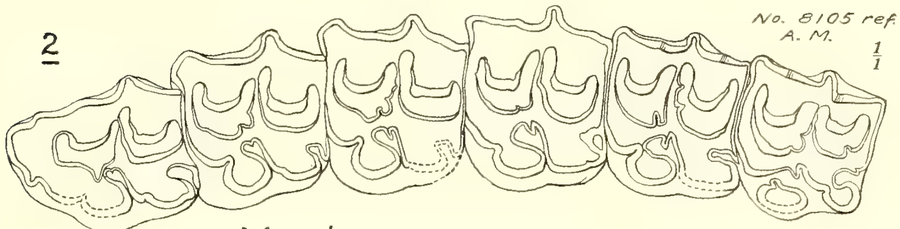
Merychippus isonesus

8



Merychippus seversus

2



Merychippus isonesus

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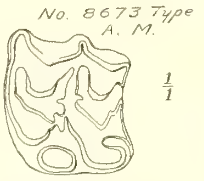

Merychippus relictus

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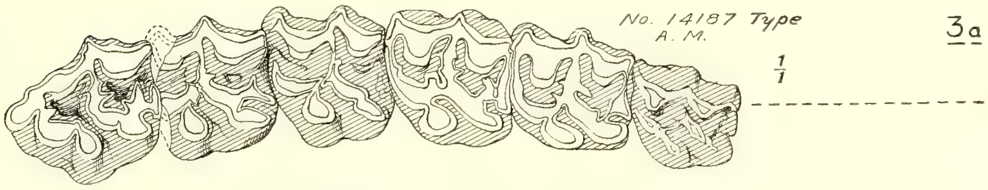
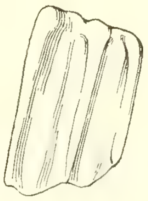


Merychippus isonesus primus

3a



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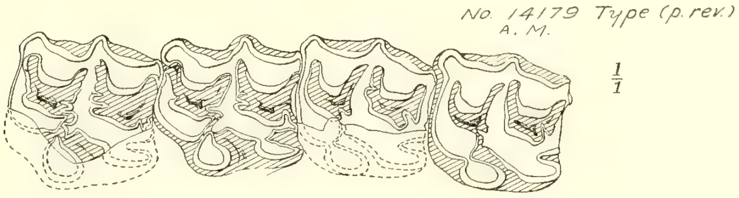

Merychippus isonesus secundus

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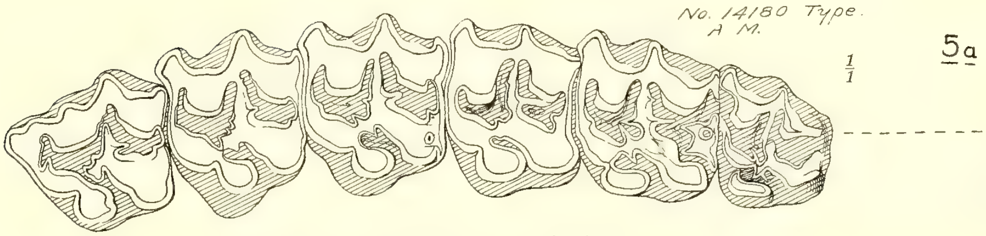
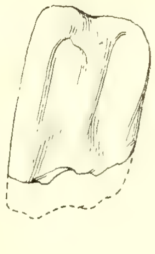


Merychippus isonesus tertius

5a



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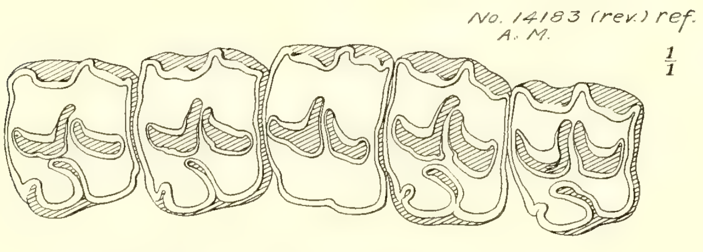
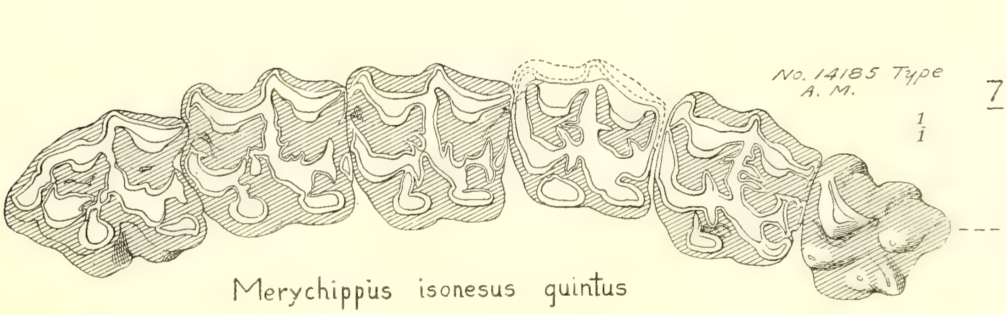


Merychippus isonesus tertius

7



Merychippus isonesus quintus

7a

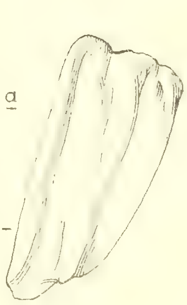


PLATE 14.

UPPER AND LOWER TEETH, *MERYCHIPPUS.*

PLATE 14.

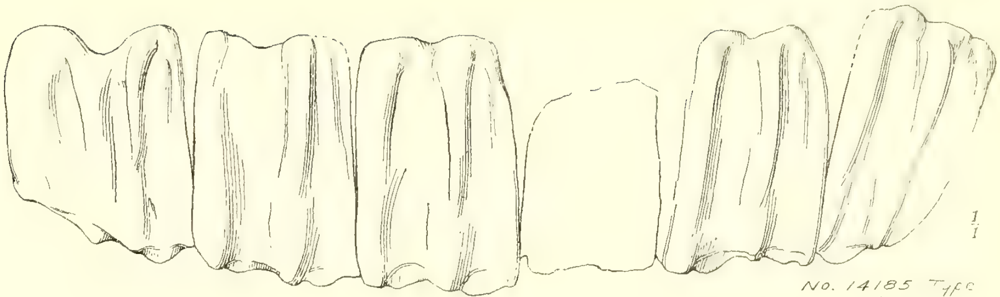
UPPER AND LOWER TEETH OF *MERYCHIPPUS* FROM THE SHEEP CREEK BEDS, NEBRASKA.

Comparison of three species from Sioux County, Nebraska. The upper teeth of the Sheep Creek specimens of *Merychippus* are compared in crown view on Plate 13, the limbs and feet on Plates 41, 45, 46, 52.

All figures natural size.

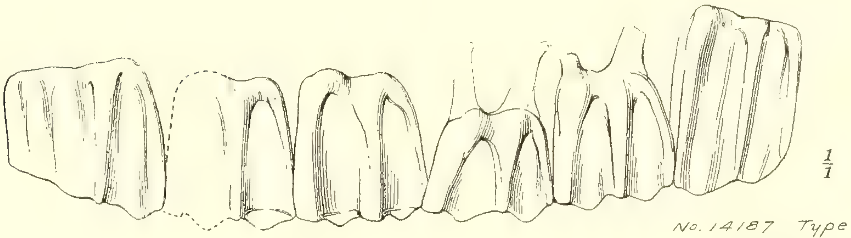
Sheep Creek, Nebr.	Middle Miocene	1. *Merychippus isonesus quintus* Osborn, type, Am. Mus. 14185. Crown view of these teeth is given on Plate 13.
"	" "	2. *Merychippus isonesus primus* Osborn, type, Am. Mus. 14187. Upper teeth, outer view. Crown view of these teeth is given on Plate 13.
"	" "	3. *Merychippus isonesus tertius* Osborn, type, Am. Mus. 14180. Outer view of upper and lower dentition. Crown view of upper teeth on Plate 13.
"	" "	4. *Merychippus isonesus primus* Osborn, type, Am. Mus. 14187. Lower teeth. Crown and outer views.

1



Merychippus isonesus quintus

2



Merychippus isonesus primus

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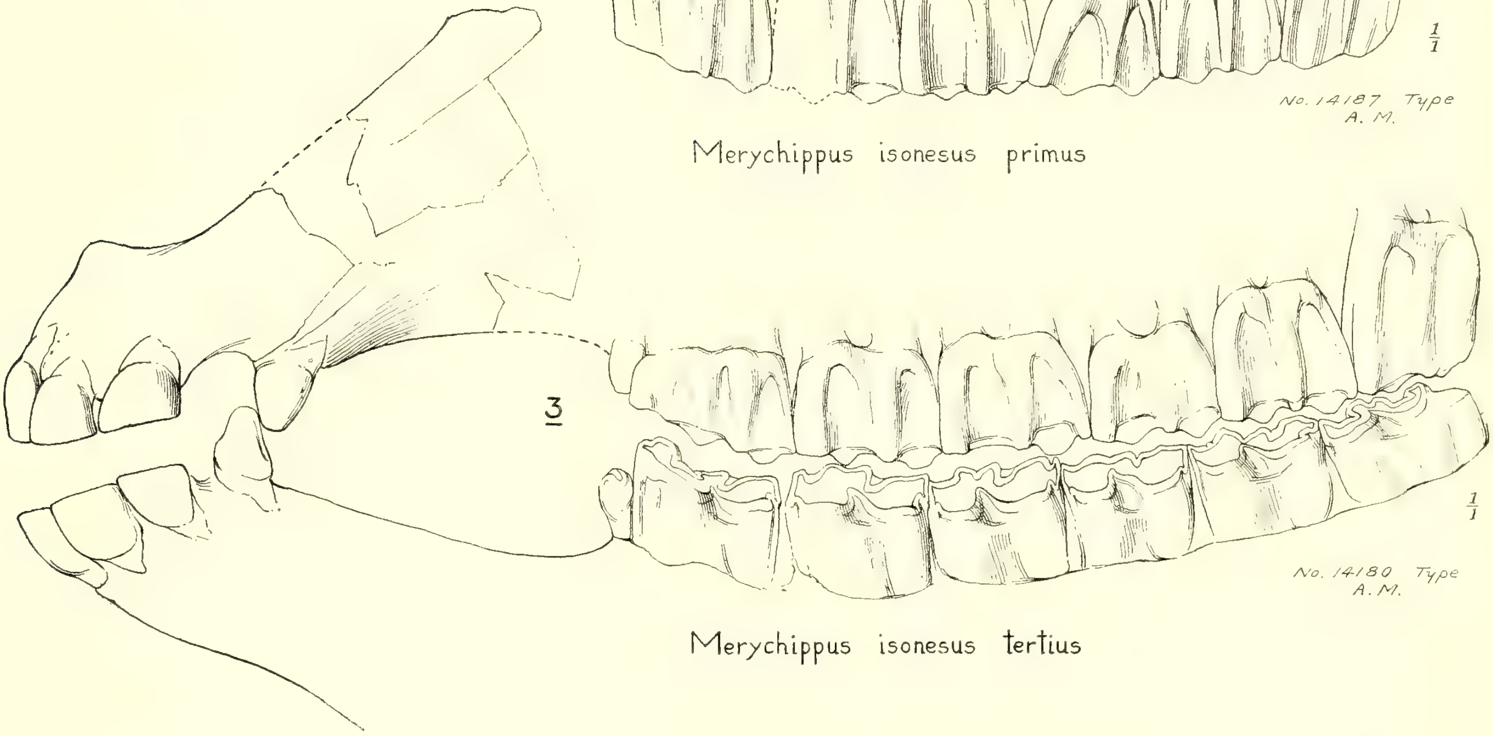

Merychippus isonesus tertius

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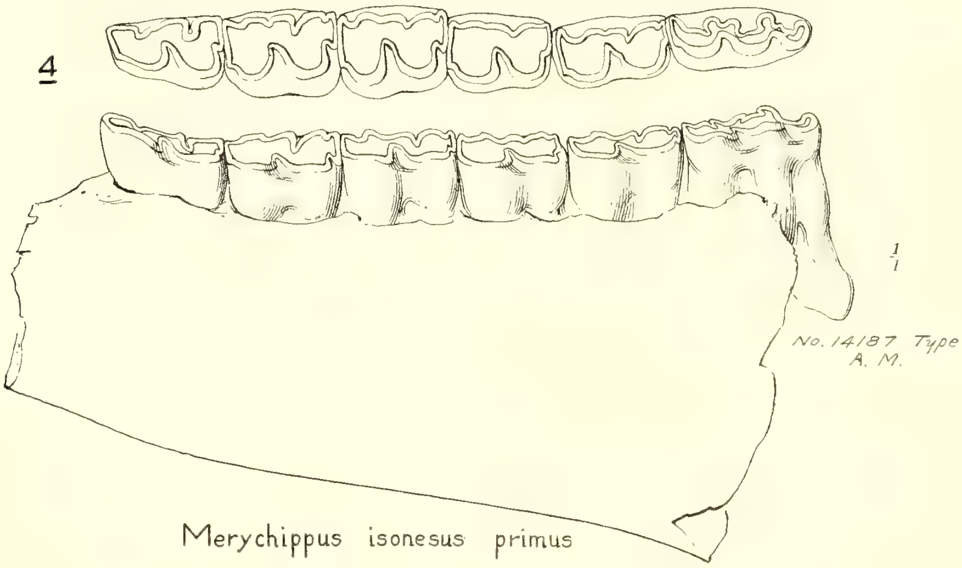


L.M.S.

Merychippus isonesus primus

PLATE 15.

UPPER TEETH, *MERYCHIPPUS*.

PLATE 15.

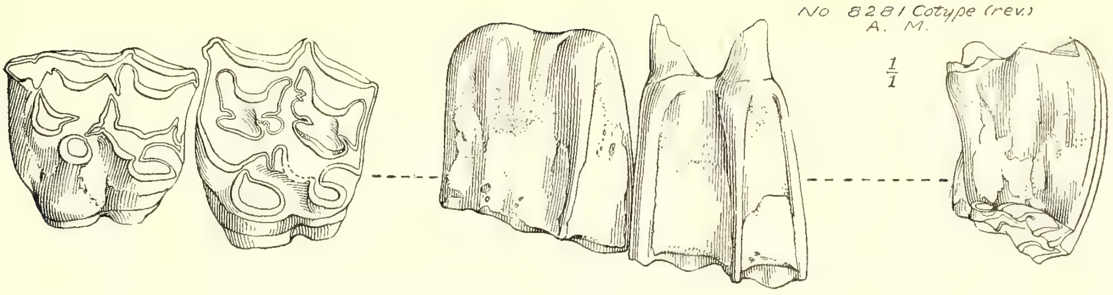
UPPER TEETH OF *MERYCHIPPUS* FROM NORTHEASTERN COLORADO, THREE SPECIES FROM THE MIDDLE MIOCENE OF COLORADO.

COMPARISON OF EARLY AND LATE STAGES OF WEAR.

All figures natural size.

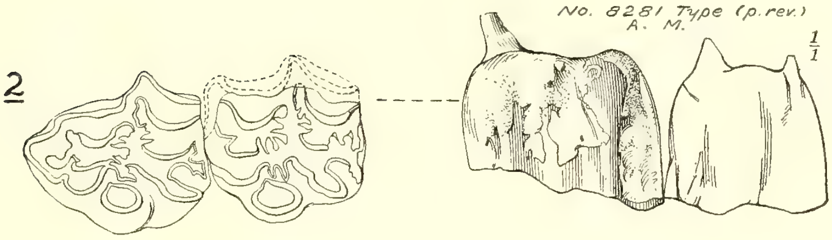
Pawnee Creek, northeastern Col.	Middle Miocene	1. *Merychippus sphenodus* Cope, cotype, Am. Mus. 8281 (reversed in drawing). This "cotype" belongs to a distinct species, more primitive than the type.
“ “ “ “	“ “	2. *M. sphenodus* Cope, type, Am. Mus. 8281. Teeth little worn (partly reversed in drawing).
“ “ “ “	“ “	3. *M. sphenodus* Cope, referred specimen, Am. Mus. 9400. Teeth well worn.
“ “ “ “	“ “	4. *M. campestris* Gidley, type Am. Mus. 9096. Teeth little worn.
“ “ “ “	“ “	5. *M. campestris* Gidley, referred specimen, Am. Mus. 9459 (reversed in drawing). Teeth much worn.
“ “ “ “	“ “	6. *M. proparvulus* Osborn, type, Am. Mus. 9394. Teeth much worn.
“ “ “ “	“ “	7. *M. proparvulus* Osborn, paratype, Am. Mus. 9398. Teeth much worn.

1



Merychippus sphenodus

2



Merychippus sphenodus

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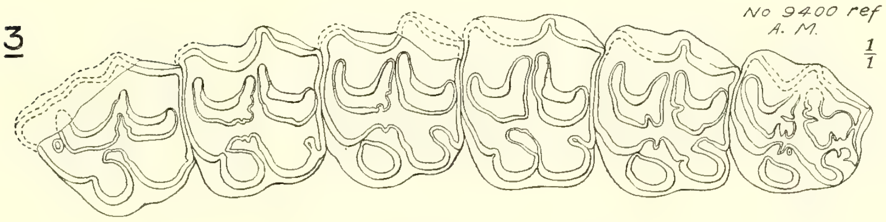

Merychippus sphenodus

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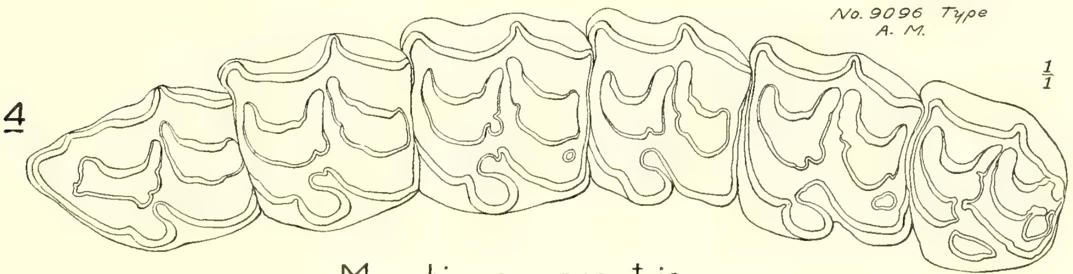

Merychippus campestris

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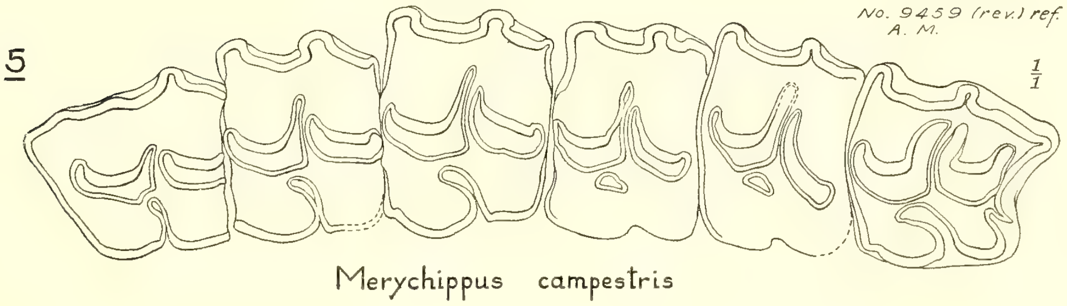

Merychippus campestris

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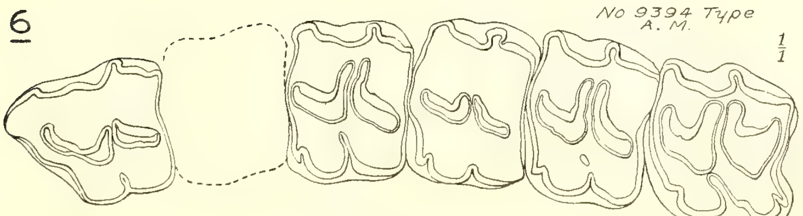

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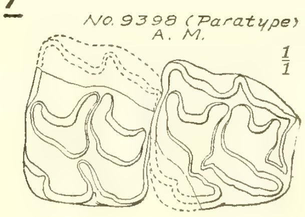


L.M.S.

Merychippus proparvulus

PLATE 16.

UPPER TEETH, *MERYCHIPPUS*.

PLATE 16.

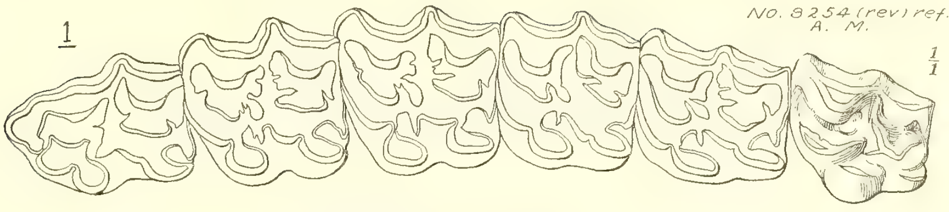
UPPER TEETH OF *MERYCHIPPUS* FROM NORTHEASTERN COLORADO.

COMPARISON OF UPPER TEETH OF *M. SEJUNCTUS* AND *M. PANIENSIS.*

All figures natural size.

Pawnee Creek, northeastern Col.	Middle Miocene	1. *Merychippus sejunctus* Cope, referred specimen, Am. Mus. 8254 (reversed in drawing). Teeth little worn.
" " " "	" "	2. *M. sejunctus* Cope, referred specimen, Am. Mus. 9414 (m^3 reversed in drawing). Teeth moderately worn.
" " " "	" "	3. *M. sejunctus* Cope, type, Am. Mus. 8291, Teeth much worn.
" " " "	" "	4. *M. paniensis* Cope, referred specimen, Am. Mus. 9460 (m^{2-3} reversed in drawing). Teeth little worn.
" " " "	" "	5. *M. paniensis* Cope, referred specimen, Am. Mus. 9093. Teeth moderately worn.
" " " "	" "	6. *M. paniensis* Cope, referred specimen, Am. Mus. 9039 (reversed in drawing). Teeth much worn.

1



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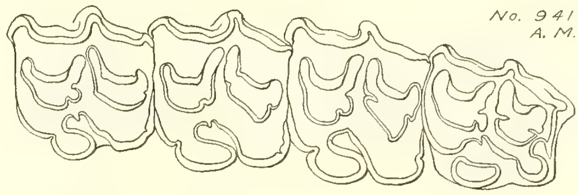
A. M.

1/1

Merychippus sejunctus

2



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Merychippus sejunctus

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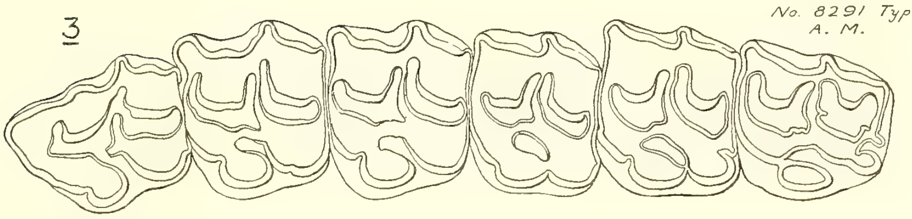

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Merychippus sejunctus

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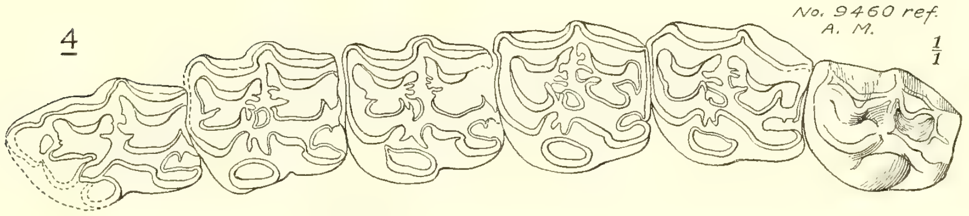
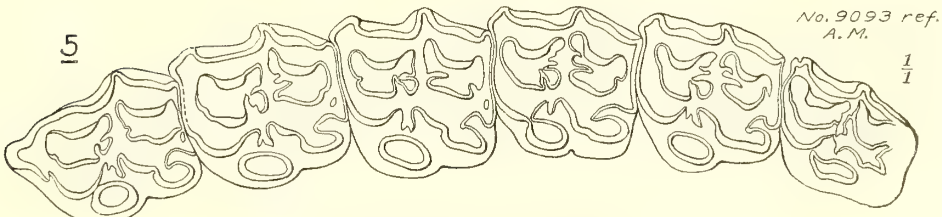


No. 9460 ref.
A. M.

1/1

Merychippus paniensis

5

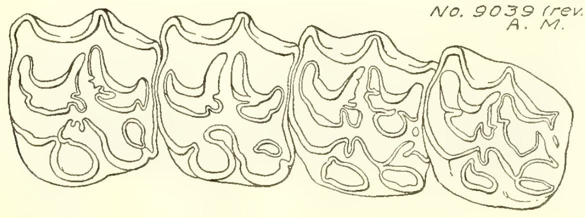


No. 9093 ref.
A. M.

1/1

Merychippus paniensis

6



No. 9039 (rev.) ref.
A. M.

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Merychippus paniensis

L.M.S.

PLATE 17.

UPPER TEETH, *MERYCHIPPUS.*

PLATE 17.

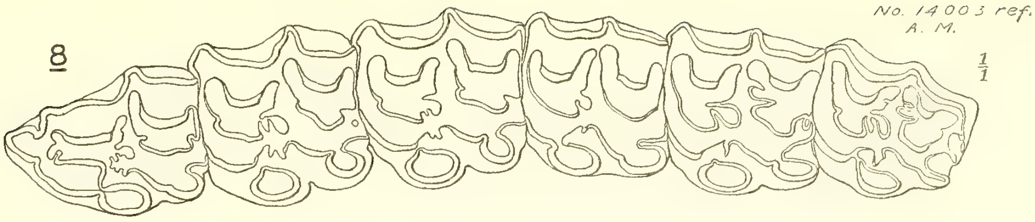
UPPER TEETH OF *MERYCHIPPUS.*

COMPARISON OF VARIOUS SPECIES FROM THE MIOCENE AND LOWER PLIOCENE FORMATIONS OF THE WESTERN UNITED STATES.

All figures natural size.

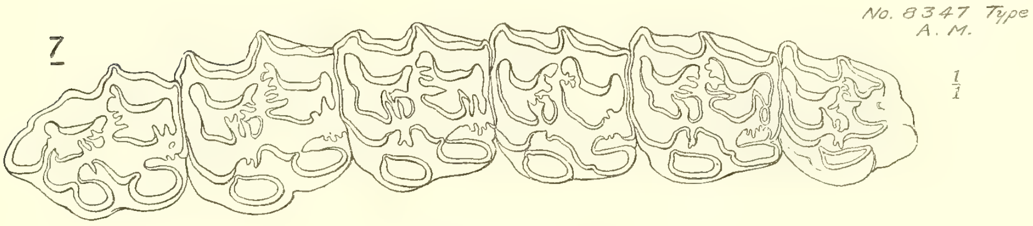
Mascall, Cottonwood Creek, Ore.	Middle Miocene	1.	*Merychippus seversus* Cope, type, Am. Mus. 8180, (?) of the right side (reversed in drawing). Little worn.
?Mascall, Oregon Desert, Ore.	?Middle “	2.	*M. relictus* Cope, type, Am. Mus. 8673, upper molar of the right side. Much worn.
Deep River, Mont.	Middle “	3.	*M. isonesus* Cope, referred specimen, Am. Mus. 8105. Much worn.
Mascall, Cottonwood Creek, Ore.	“ “	4.	*M. isonesus* Cope, type, Am. Mus. 8175.
Niobrara River, Nebr.	Lower Pliocene	5.	*Merychippus insignis* Leidy, referred specimen.
Republican River, Nebr.	“ “	6.	*M. patruus* Osborn, type, Am. Mus. 8347a. Upper teeth, moderately worn.
Driftwood Creek, Nebr.	“ “	7.	*M. republicanus* Osborn, type, Am. Mus. 8347, upper teeth, moderately worn. (This is the specimen figured by Cope under the name *Hippotherium speciosum.*)
Snake Creek, Sioux County, Nebr.	?Lower Pliocene	8.	*M. calamarius* Cope, referred specimen, Am. Mus. 14003. P^2 and m^3 are drawn from other (unnumbered) individuals from the same quarry. (M^3 reversed in drawing.)

8



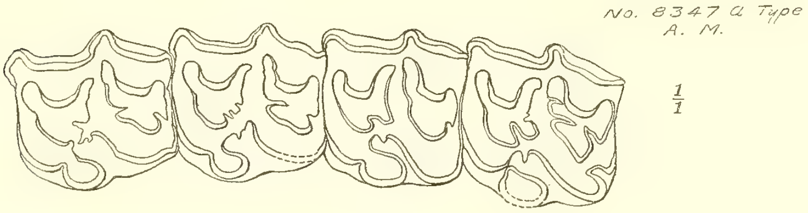
Merychippus calamarius

7



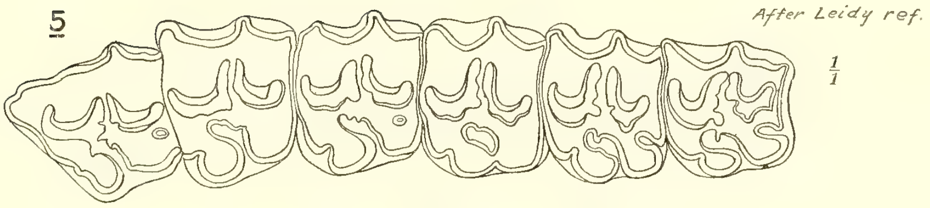
Merychippus republicanus

6



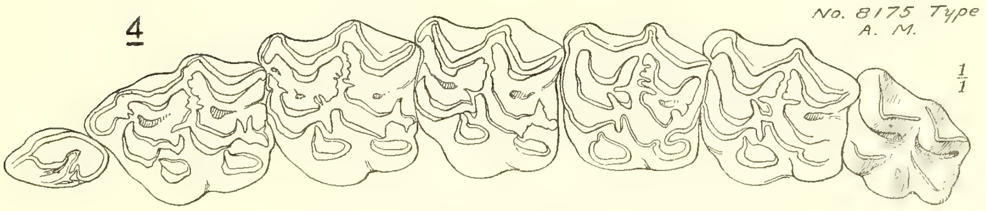
Merychippus patruus

5



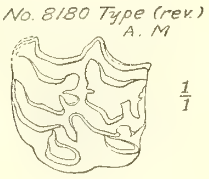
Merychippus insignis

4



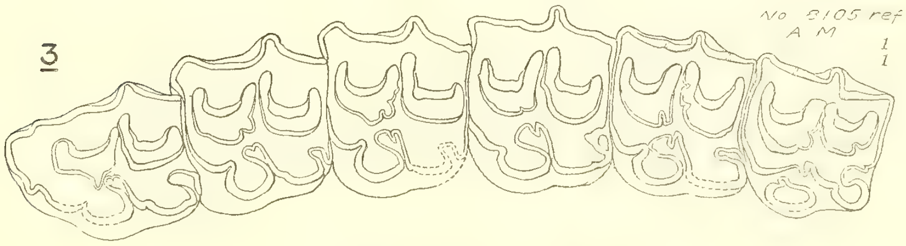
Merychippus isonesus

1



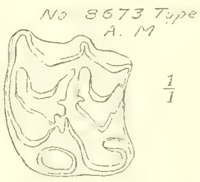
Merychippus seversus

3



Merychippus isonesus

2



Merychippus relictus

L. M. S.

PLATE 18.

SUPERIOR AND INFERIOR MOLAR TOOTH TYPE OF *MERYCHIPPUS*.

PLATE 18.

CONSTRUCTION OF TEETH IN *MERYCHIPPUS.*

COMPARATIVE VIEWS OF TYPICAL UPPER PREMOLAR, P^4, AND LOWER MOLAR, M_2, IN DIFFERENT SPECIES. FROM TEETH PREFORMED IN THE JAW BEFORE ERUPTION AND DEPOSITION OF CEMENT.

All figures natural size.

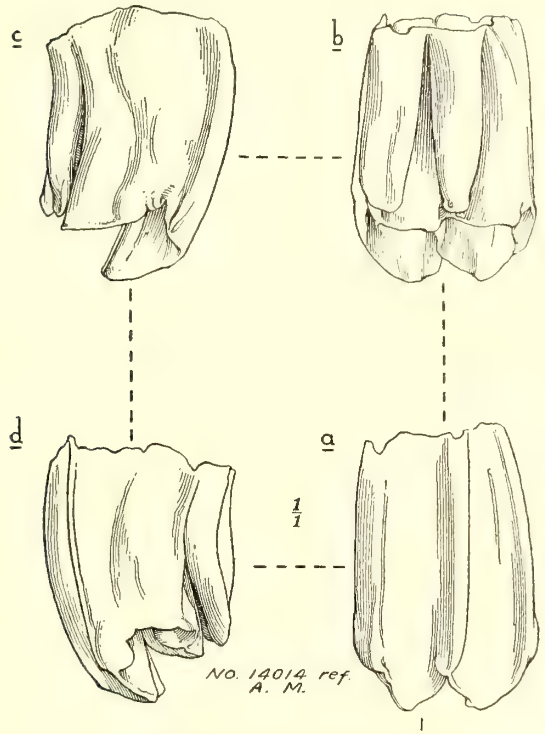
Left column.

Pawnee Creek, Col.	Middle Miocene	1.	*Merychippus paniensis* Cope, referred specimen, Am. Mus. 9422. *c*, Anterior view, *b*, internal view.
Snake Creek, Sioux Co., Nebr.	?Lower Pliocene	2.	*M. calamarius* Cope, referred specimen, Am. Mus. 14014. *a*, External view, *b*, internal view, *c*, anterior view, *d*, posterior view.

Right column.

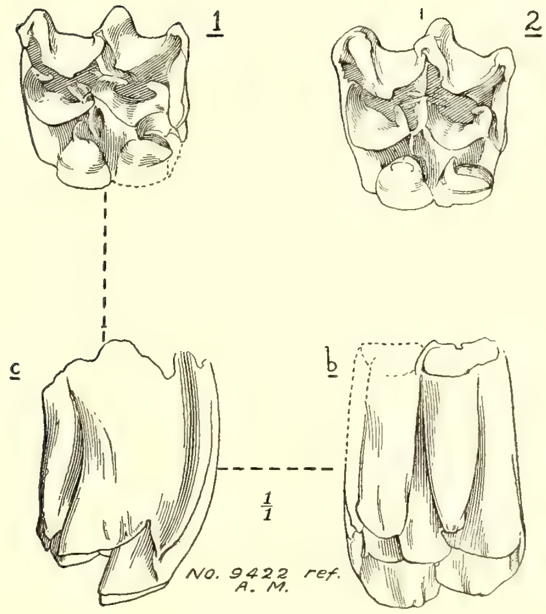
Sheep Creek, Neb.	Middle Miocene	3.	*M. isonesus primus* Osborn, type, Am. Mus. 14187 (reversed in drawing).
Pawnee Creek, Col.	" "	4.	*M. sphenodus* Cope, referred specimen, Am. Mus. 9408.
" " "	" "	5.	*M. paniensis*, referred specimen, Am. Mus. 8255.
Snake Creek, Sioux Co., Nebr.	Lower Pliocene	6.	*M. calamarius* Cope, referred specimen, Am. Mus. 13901a. *a*, External view, *b*, internal view, *c*, anterior view, *d*, posterior view.

Note the marked progression in the length of the molar crowns and the size of the molar teeth exhibited in the lower grinding tooth of *M. isonesus primus* Osborn (Fig. 3) and the corresponding tooth of *M. calamarius* Cope (Fig. 6).



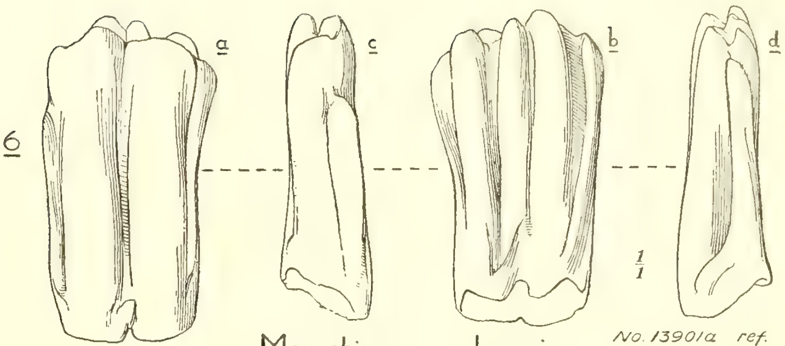
No. 14014 ref. A. M.

Merychippus calamarius

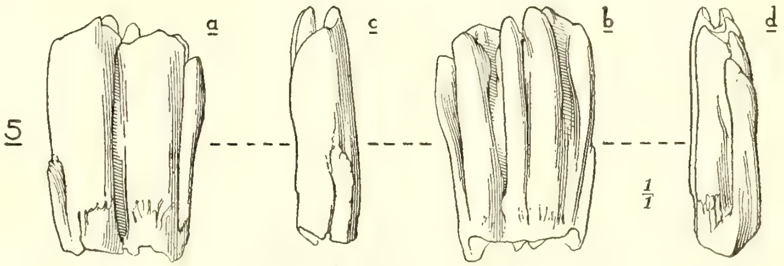


No. 9422 ref. A. M.

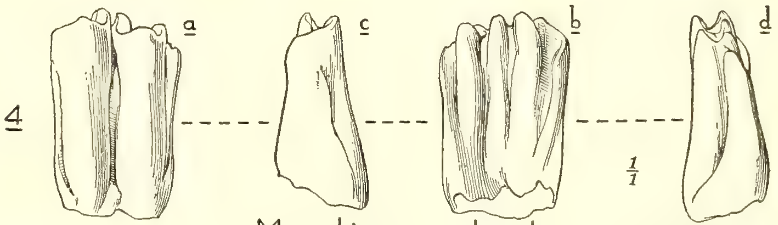
L.M.S. Merychippus paniensis



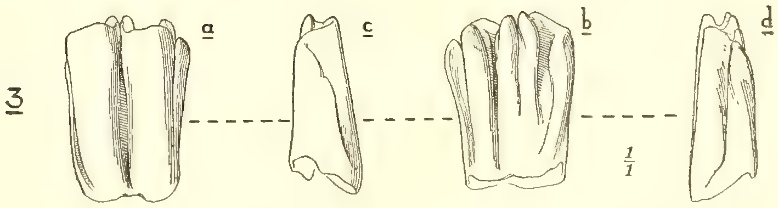
Merychippus calamarius No. 13901a ref. A. M.



Merychippus paniensis No. 8255. ref. A. M.



Merychippus sphenodus No. 9408 ref. A. M.



Merychippus isonesus primus No. 14187 Type (rev.) A. M.

PLATE 19.

LOWER TEETH, *MERYCHIPPUS.*

PLATE 19.

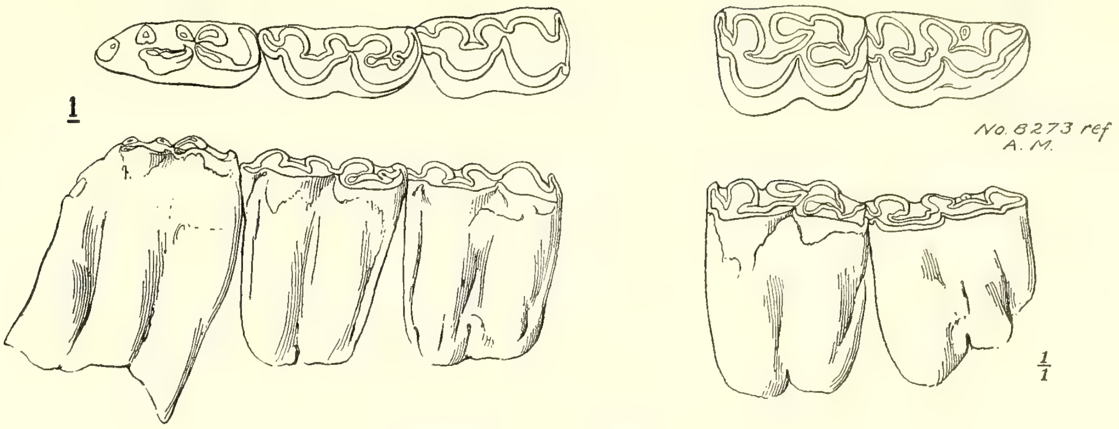
LOWER TEETH OF *MERYCHIPPUS* FROM NORTHEASTERN COLORADO.

COMPARISON OF THE TEETH AT DIFFERENT STAGES OF WEAR IN TWO SPECIES FROM THE MIDDLE MIOCENE OF COLORADO.
THE UPPER TEETH OF THE SAME INDIVIDUALS ARE FIGURED ON PLATES 15, 16.

All figures natural size.

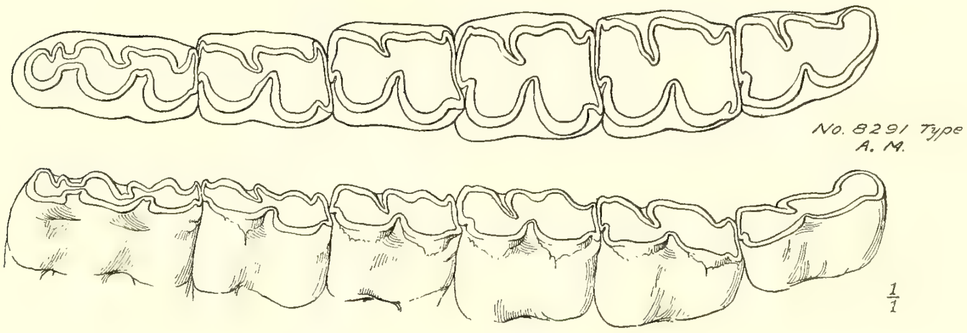
Pawnee Creek, Col.	Middle Miocene	1. *Merychippus sejunctus* Cope, referred specimen, Am. Mus. 8273. Teeth little worn.
“ “ “	“ “	2. *M. sejunctus* Cope, type, Am. Mus. 8291. Teeth well worn.
“ “ “	“ “	3. *M. campestris* Gidley, type, Am. Mus. 9096. Teeth little worn. (Drawn from left lower series reversed, the right ramus being diseased.)
“ “ “	“ “	4. *M. campestris* Gidley, referred specimen, Am. Mus. 9459. Teeth much worn.

1



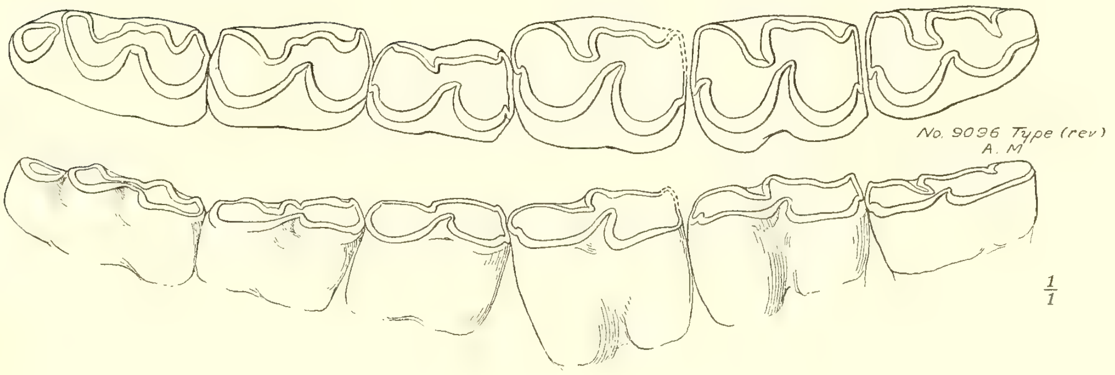
Merychippus sejunctus

2



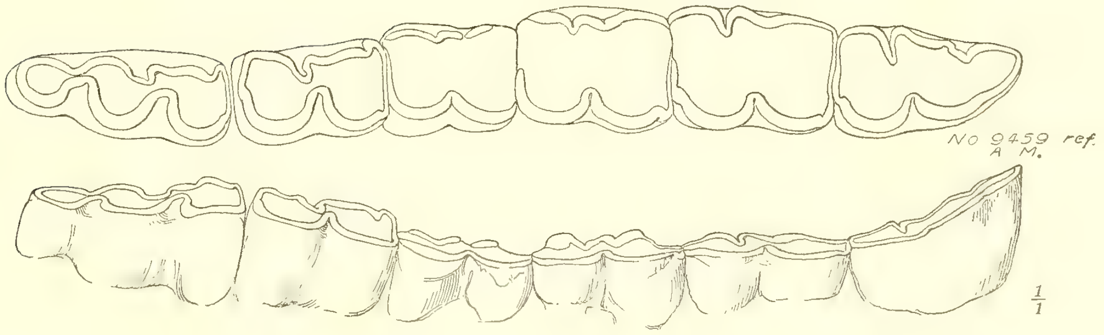
Merychippus sejunctus

3



Merychippus campestris

4



Merychippus campestris

PLATE 20.

SKULL AND LOWER TEETH, *MERYCHIPPUS.*

PLATE 20.

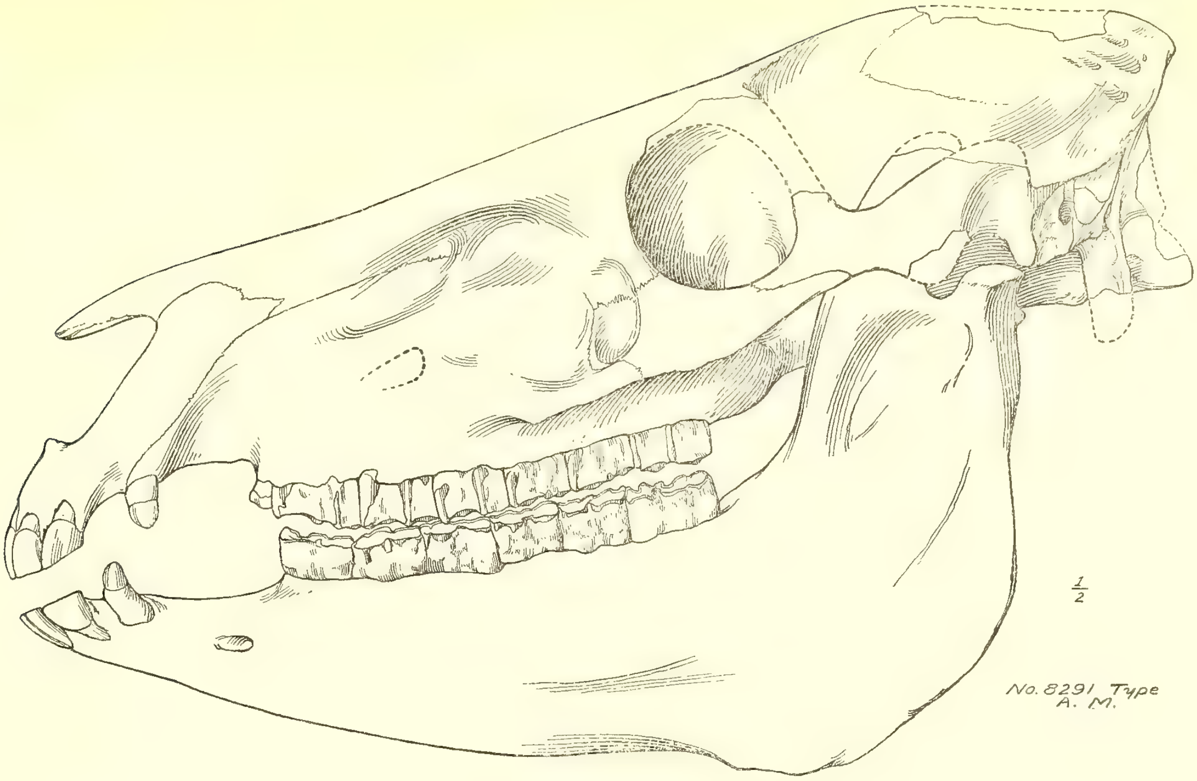
SKULL AND LOWER TEETH OF *MERYCHIPPUS* FROM NORTHEASTERN COLORADO.

COMPARISON OF THE OUTER AND CROWN VIEWS OF THE TEETH OF FOUR SPECIES FROM COLORADO.

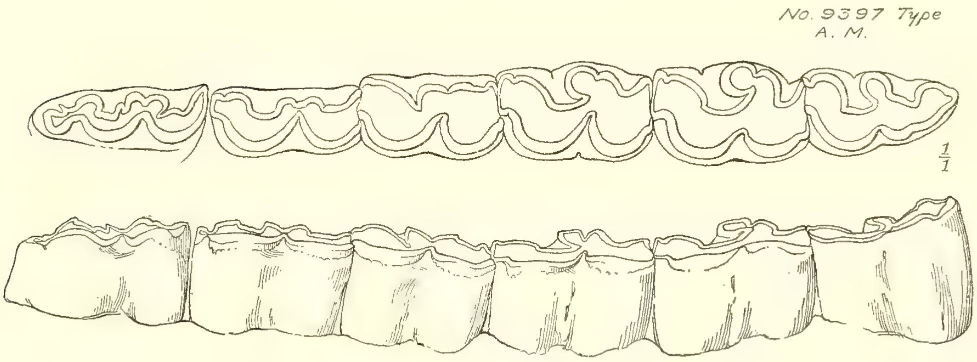
The limbs and feet of these skeletons are compared on Plates 44, 47, 49, and the upper teeth of *M. proparvulus* from another specimen on Plate 15, also feet, Plate 54.

Skull one-half natural size. Teeth natural size.

Pawnee Creek	Middle to Upper Miocene	*Merychippus sejunctus*, type skull, Am. Mus. 8291.
" "	"	1. *M. eoplacidus* Osborn, type, Am. Mus. 9397. Teeth little worn.
" "	"	2. *M. eohipparion* Osborn, type, Am. Mus. 9402. Teeth almost unworn, m_3 not fully erupted.
" "	"	3. *M. proparvulus* Osborn, paratype, Am. Mus. 9398. Teeth about half worn.

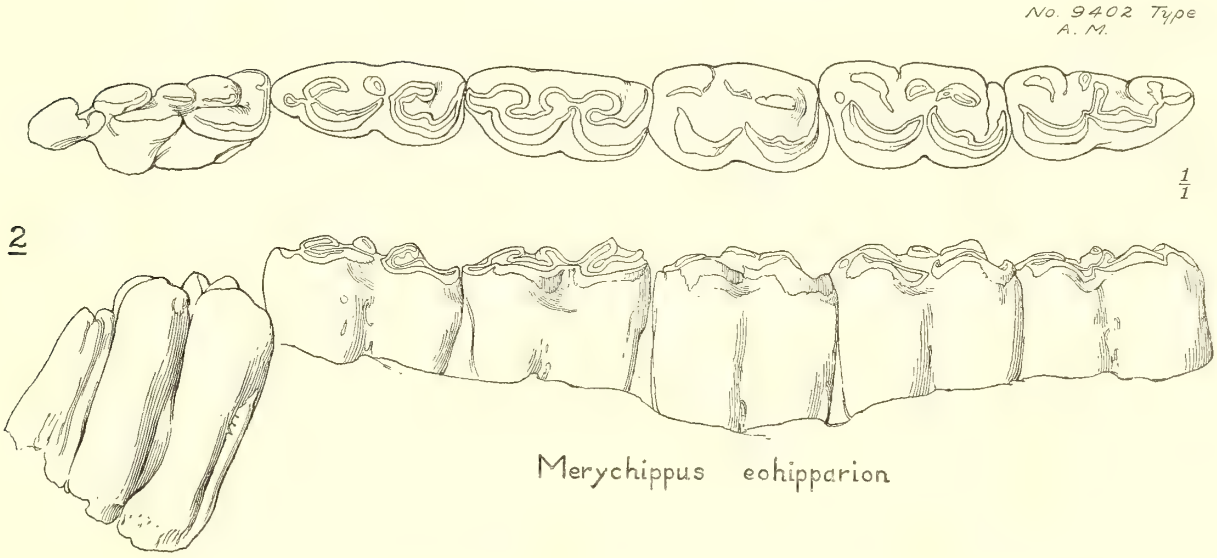


Merychippus sejunctus

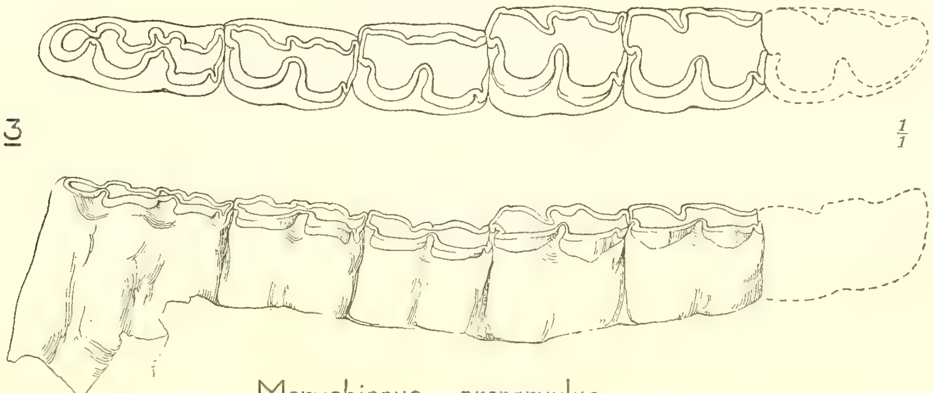


1

Merychippus eoplacidus



Merychippus eohipparion



3

Merychippus proparvulus

L.M.S.

PLATE 21.

FACE, *PROTOHIPPUS.*

PLATE 21.

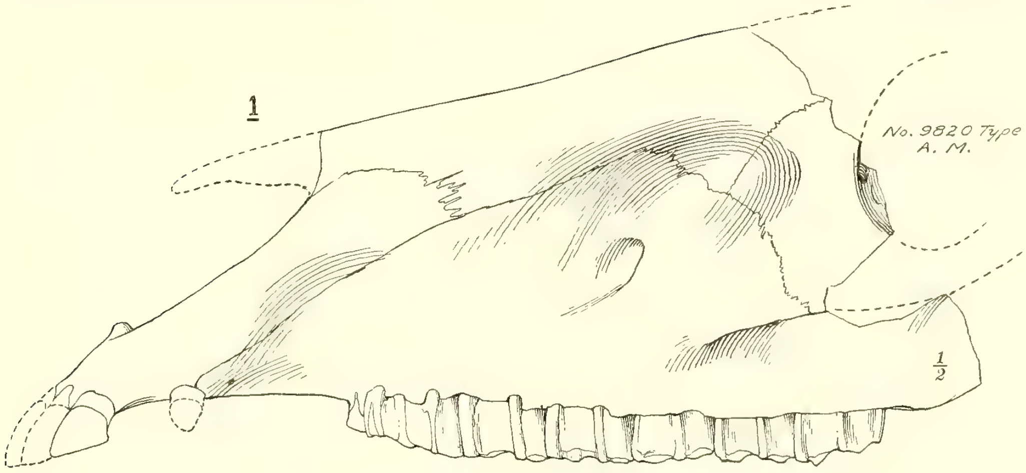
PREORBITAL FOSSÆ IN *PROTOHIPPUS*.

COMPARISON OF FACIAL PART OF SKULL IN THREE SPECIES FROM THE UPPER MIOCENE OF NEBRASKA AND SOUTH DAKOTA.

All figures one-half natural size.

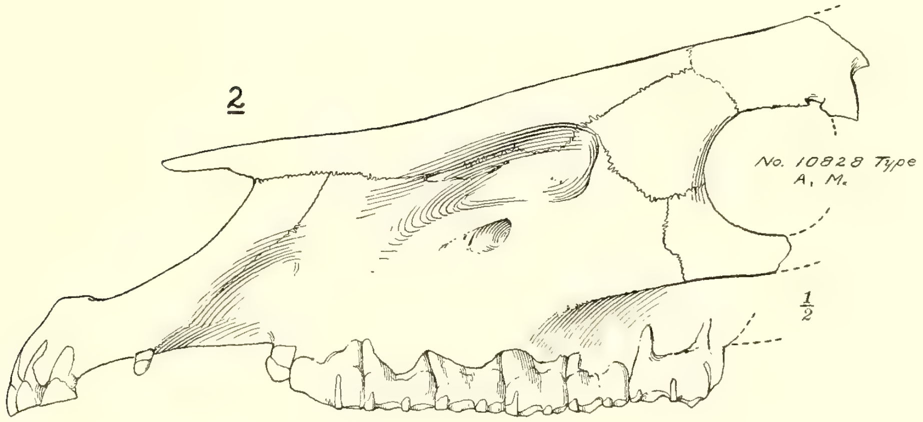
Little White River, So. Dak.	Lower Pliocene	1. *Protohippus simus* Gidley, type, Am. Mus. 9820. Lachrymal fossa shallow; no malar fossa.
Niobrara River, Nebraska	" "	2. *P. niobrarensis* Gidley, type, Am. Mus. 10828. Lachrymal fossa restricted, moderately deep, anterior in position; no malar fossa.
Little White River, So. Dak.	" "	3. *P. perditus* Leidy, neotype (Gidley), Am. Mus. 10838. Juvenile skull; lachrymal fossa restricted, rather shallow; no malar fossa.

1



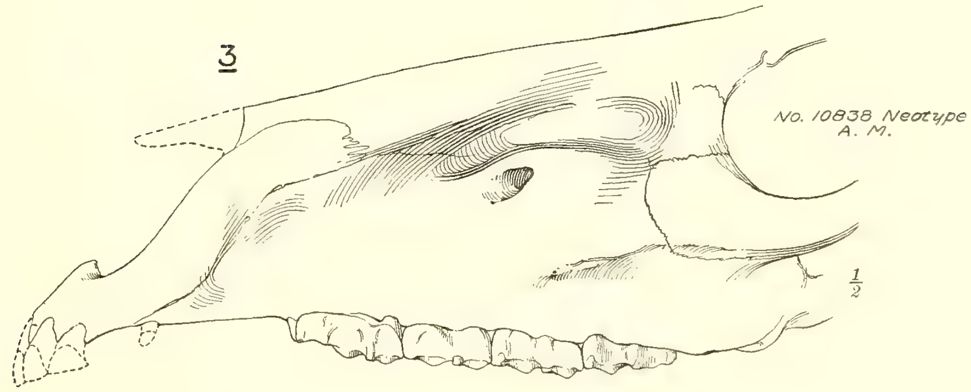
Protohippus simus

2



Protohippus niobrarensis

3



L.M.S.

Protohippus perditus

PLATE 22.

TYPE TEETH, *PROTOHIPPUS.*

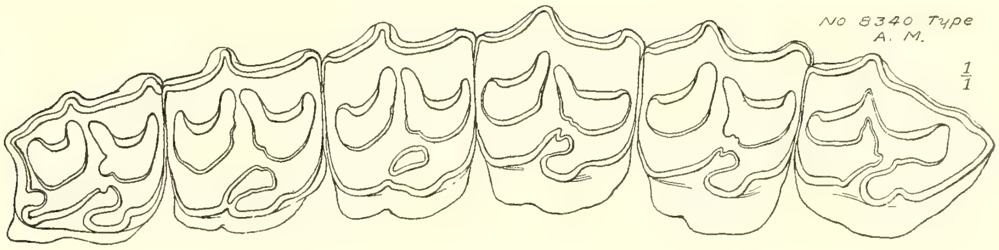
PLATE 22.

TYPES OF THREE SPECIES OF *PROTOHIPPUS*.

All figures natural size.

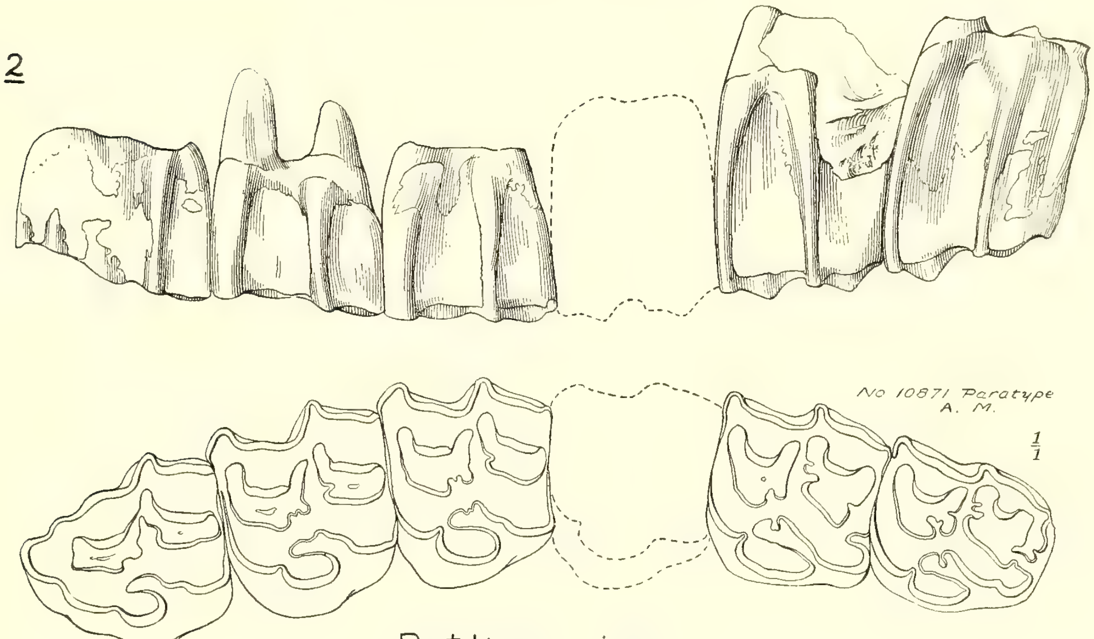
Republican River, Driftwood Creek, Nebr.	Lower Pliocene	1.	*Protohippus secundus* Osborn, type, Am. Mus. 8340.
Little White River, So. Dak.	" "	2.	*P. perditus simus* Gidley, paratype, Am. Mus. 10871. A portion of the upper jaw containing all the large cheek teeth except m^1.
Republican River, Nebr.	" "	3.	*P. profectus* Cope, type, Am. Mus. 8349. Six isolated superior molar teeth of the left side.

1



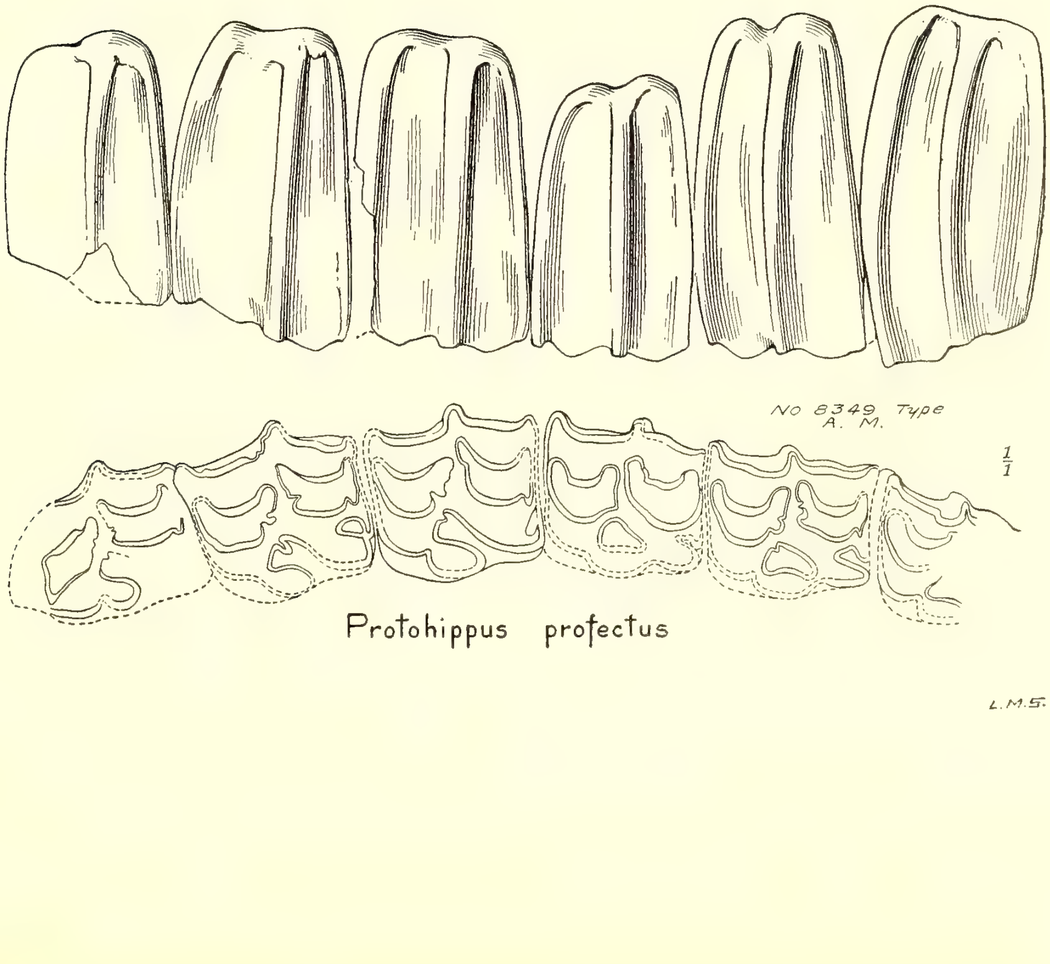
Protohippus secundus

2



Protohippus simus

3



Protohippus profectus

L.M.S.

PLATE 23.

FACE, *PROTOHIPPUS*, *PLIOHIPPUS*.

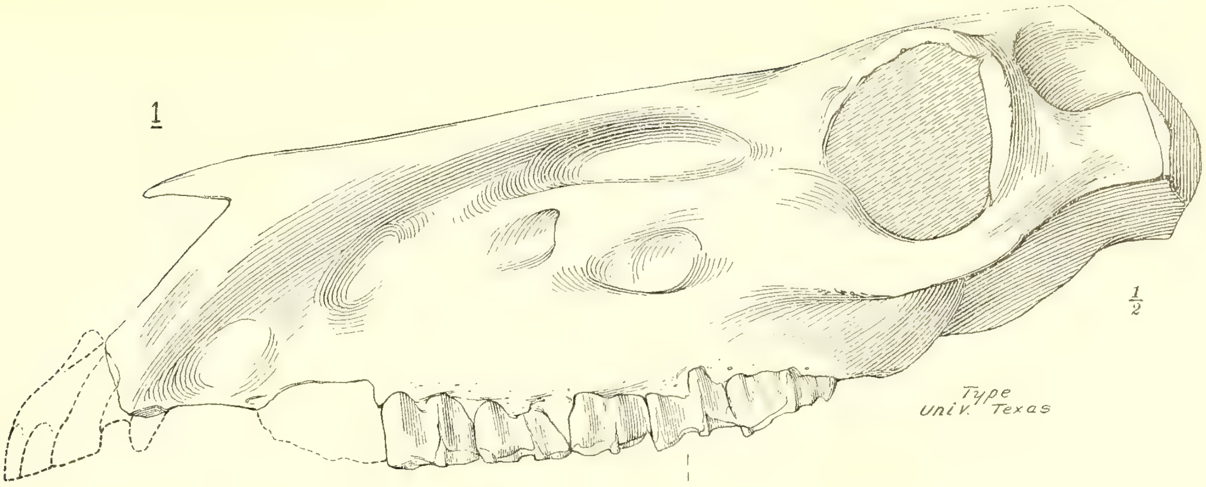
PLATE 23.

SKULLS OF *PROTOHIPPUS* AND *PLIOHIPPUS* FROM THE UPPER MIOCENE OF TEXAS.

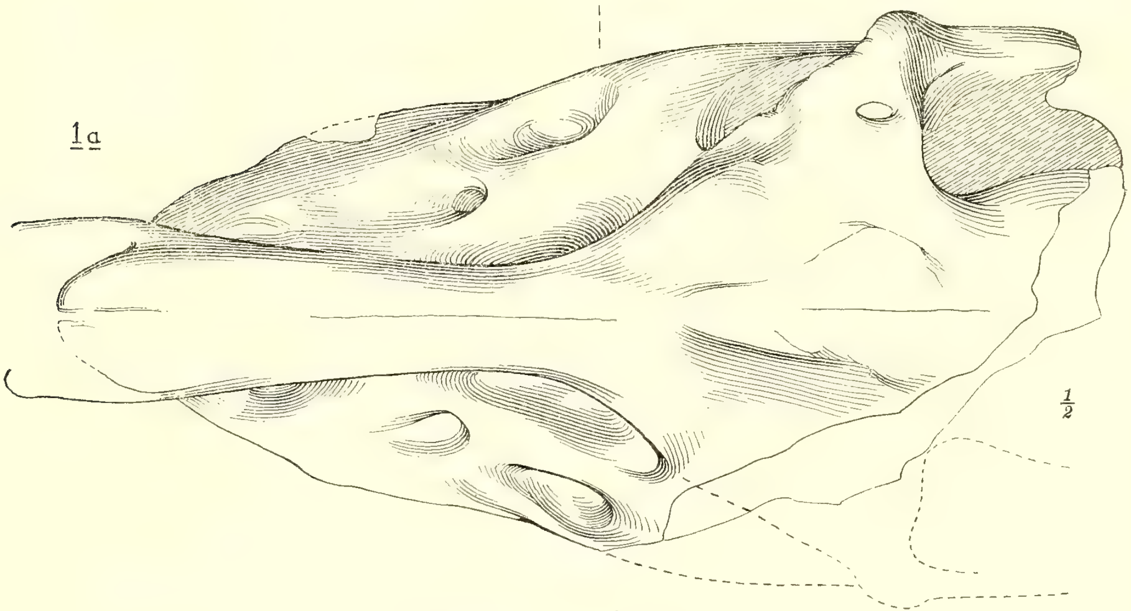
All figures one-half natural size.

Llano Estacado, Texas	Lower Pliocene	1, 1*a*. *Pliohippus fossulatus* Cope, type, Univ. of Texas Coll. (cast Am. Mus. 14395). Lachrymal and malar fossæ moderately deep, anterior in position, excavation continuing forward below nasals and premaxillæ. 1 Side view, 1*a* superior view of same skull, showing undercutting below nasals and premaxillæ.
" " "	" "	2. *Protohippus pachyops* Cope, type, Univ. of Texas Coll. (cast Am. Mus. 14394). Lachrymal fossa anterior in position, restricted, rather deep; no malar fossa. The generic and specific reference of this immature skull and jaws is somewhat doubtful.

1

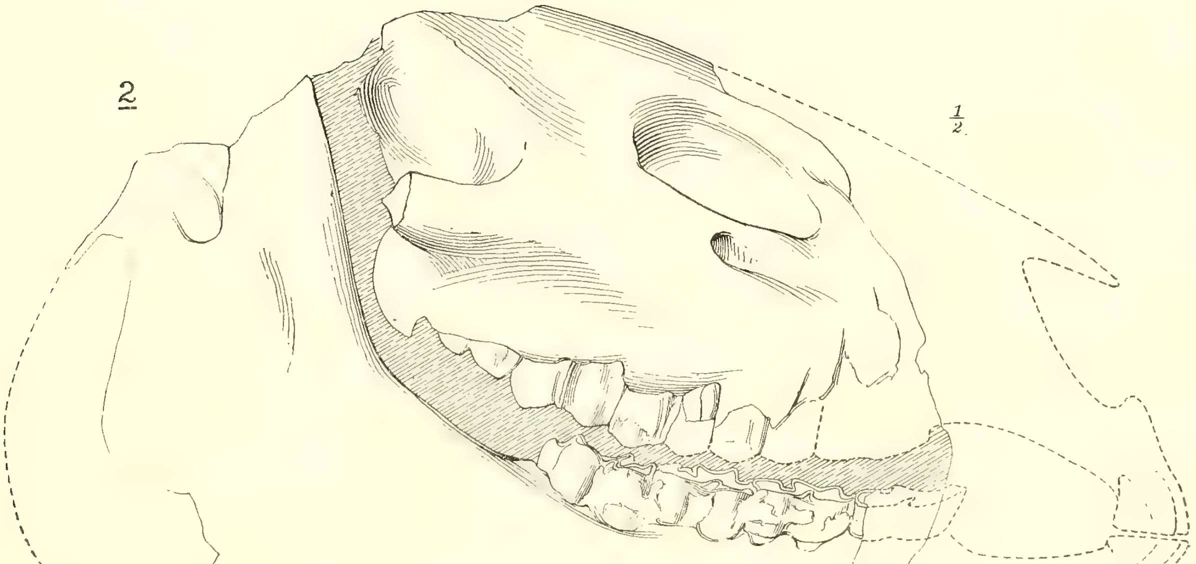


1a



Pliohippus fossulatus

2



L.M.S.

Protohippus pachyops

PLATE 24.

TEETH, *PROTOHIPPUS*, *PLIOHIPPUS*.

PLATE 24.

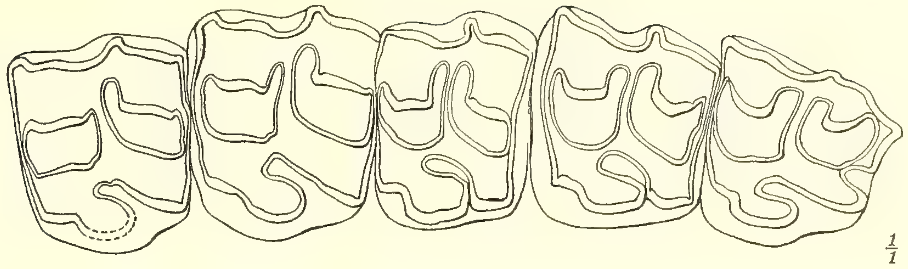
TEETH OF *PROTOHIPPUS* AND *PLIOHIPPUS* FROM NORTHERN TEXAS.

TYPE SPECIMENS FROM THE CLARENDON AND BLANCO BEDS OF TEXAS OF SPECIES DESCRIBED BY E. D. COPE IN 1892–3.

All figures natural size.

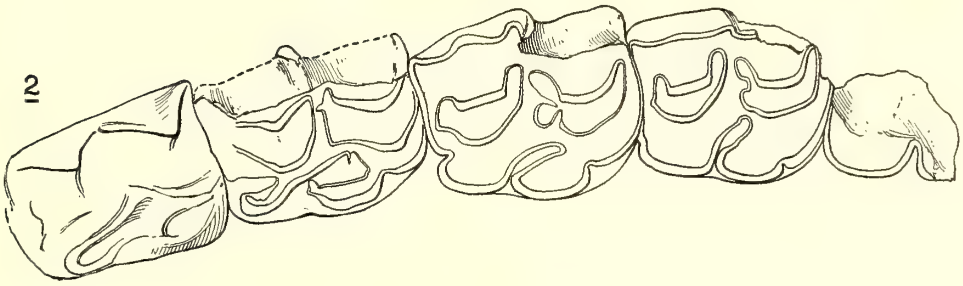
Texas	Lower Pliocene	1. *Pliohippus fossulatus* Cope, type, Univ. of Texas Coll. (cast Am. Mus. 14395), p^3–m^3, moderately worn. *a*, External view, *c*, anterior view.
"	" "	2, 2*a*. *Protohippus pachyops* Cope, Univ. of Texas Coll. (cast Am. Mus. 14394), upper and lower milk dentition of type skull, dp^2–m^2, dp_4–m_2, moderately worn.
"	Middle "	3, 4. *Pliohippus cumminsii* Cope, type, Univ. of Texas Coll. (cast Am. Mus. 14393), upper molars, 3, 4, crown and, *d*, posterior views.
"	" "	5. *Pliohippus simplicidens* Cope, type, Univ. of Texas Coll. (cast Am. Mus. 14388), upper molar. *a*, External, *c*, anterior, and crown views.
"	" "	6. *Pliohippus interpolatus* Cope, type, Univ. of Texas Coll. (cast Am. Mus. 14387), m^2. *d*, posterior, *a*, external and crown views.

1

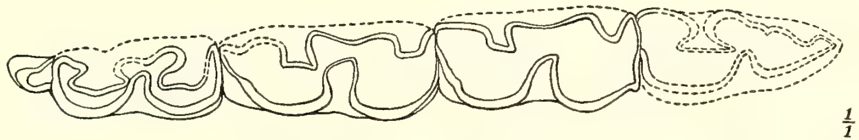


Pliohippus fossulatus Type, Univ. Tex.

2

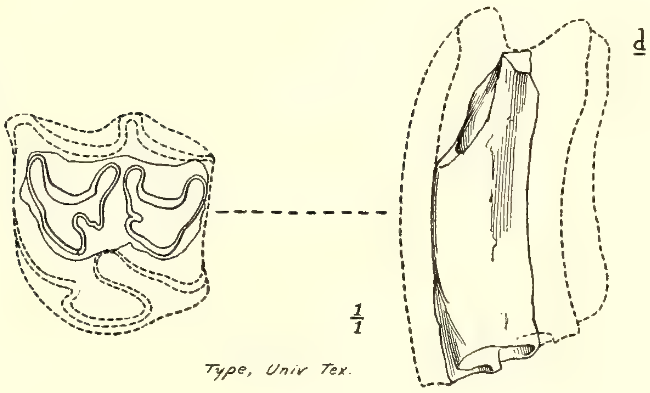


2a



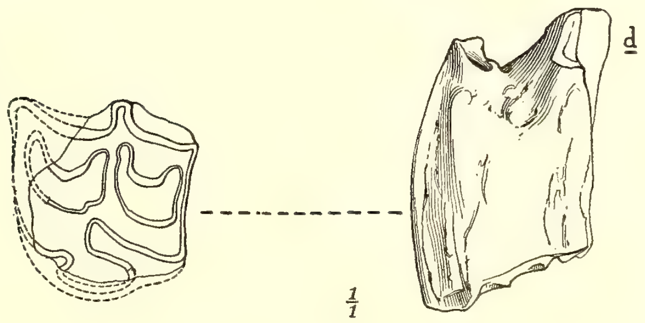
Protohippus pachyops Type, Univ. Tex.

3



Type, Univ. Tex.

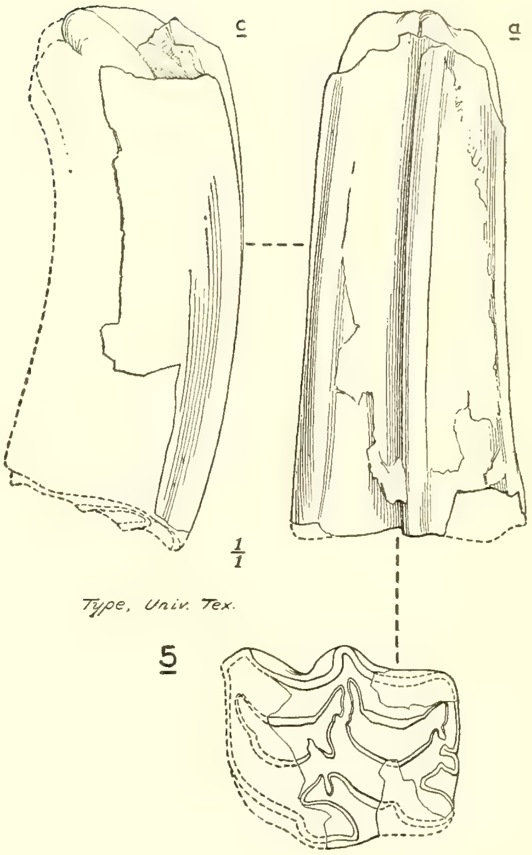
4



Type, Univ. Tex.

L.M.S. Pliohippus cumminsii

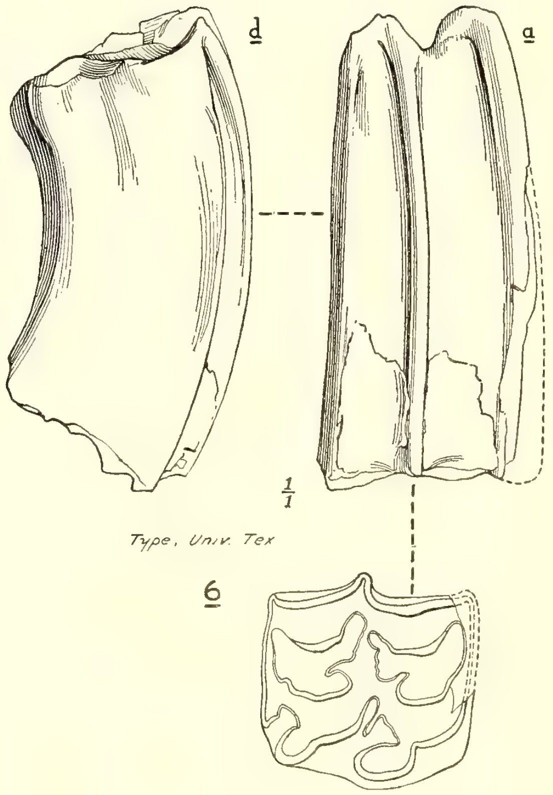
5



Type, Univ. Tex.

Pliohippus simplicidens

6



Type, Univ. Tex

Pliohippus interpolatus

PLATE 25.

MILK TEETH, *PARAHIPPUS — HIPPARION.*

PLATE 25.

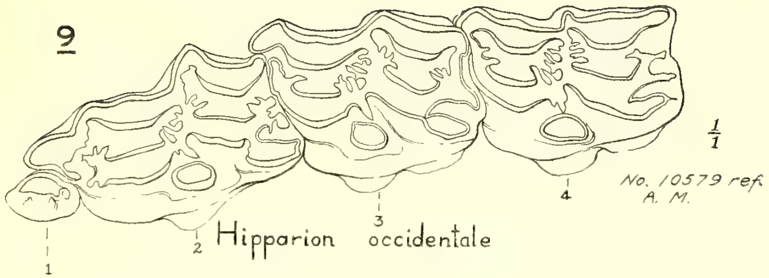
UPPER MILK TEETH OF *PARAHIPPUS, MERYCHIPPUS, PROTOHIPPUS, PLIOHIPPUS,* AND *HIPPARION.*

DECIDUOUS PREMOLARS IN DIFFERENT SPECIES OF *PARAHIPPUS, MERYCHIPPUS, PROTOHIPPUS, HIPPARION,* AND *PLIOHIPPUS.*

All figures natural size.

Pine Ridge, So. Dak.	Lower	Miocene	1.	*Parahippus pristinus* Osborn, referred specimen, Am. Mus. 12915. Primitive stage of *Parahippus.*
Niobrara River, Nebr.	“	Pliocene	2.	*Parahippus cognatus* Leidy, type, drawn from cast Am. Mus. 10772. Progressive stage of *Parahippus.*
Bijou Hills, Missouri River,	“	“	3.	*Merychippus insignis* Leidy, type, dp^{2-3}, (drawn from cast Am. Mus. 10770, reversed in drawing). Early stage of *Merychippus.*
Sheep Creek, Sioux Co., Nebr.	Middle	Miocene	4.	*Merychippus isonesus primus* Osborn, referred specimen, Am. Mus. 14187d. Earliest stage of *Merychippus.*
Pawnee Creek, Col.	“	“	5.	*Merychippus paniensis* Cope, referred specimen, Am. Mus. 9413, dp^4, well worn, found in place with m^{1-2} and preformed p^4 (reversed in drawing).
Snake Creek, Nebr.	Lower	Pliocene	6.	*Merychippus* ?sp., referred specimen, Am. Mus. 14010, dp^{1-3} of the left side.
Upper Pawnee Creek, Col.	“	“	7.	*Protohippus proplacidus* Osborn, type, Am. Mus. 9115*b*, dp^2–m^1 of the left side (reversed in drawing).
Little White River, So. Dak.	“	“	8.	*Protohippus perditus* Leidy, neotype (Gidley), Am. Mus. 10838, dp^1–m^1 of the left side.
			9.	*Hipparion occidentale* Leidy, referred specimen, Am. Mus. 10579, dp^{1-4} of the left side.
Niobrara River, Nebr.	“	“	10.	*Pliohippus mirabilis* Leidy, type, U. S. Nat. Mus. 569, dp^{3-4} of the right side.
Little White River, So. Dak.	“	“	11.	*Pliohippus supremus* Leidy, referred specimen, Am. Mus. 10844, dp^{2-4} of the right side.
“ “ “ “ “	“	“	12.	*Pliohippus pernix* Marsh, referred specimen, Am. Mus. 10836, dp^1–m^1 of the right side.
Sheep Creek, Sioux Co., Nebr.	“	“	13.	*Pliohippus interpolatus* Cope, referred specimen, Am. Mus. 13900a, dp^4 of the right side. Progressive stage of *Pliohippus.*

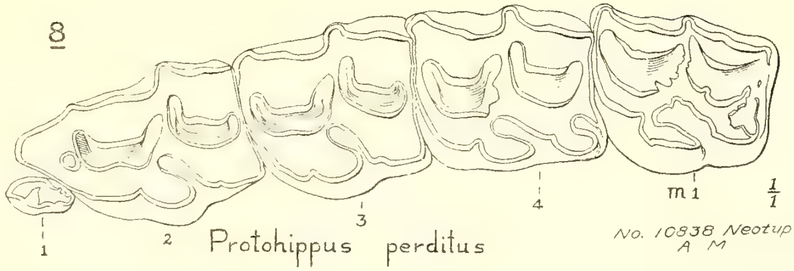
9



No. 10579 ref. A. M.

Hipparion occidentale

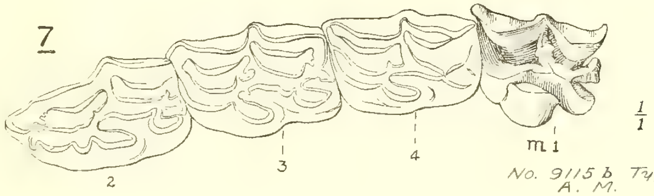
8



No. 10838 Neotype A. M.

Protohippus perditus

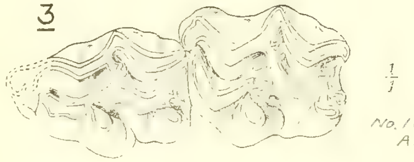
7



No. 9115 b Type (rev.) A. M.

Protohippus proplacidus

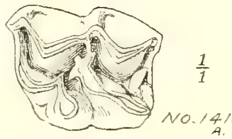
3



No. 10770 Type (Cast rev.) A. M.

Merychippus insignis

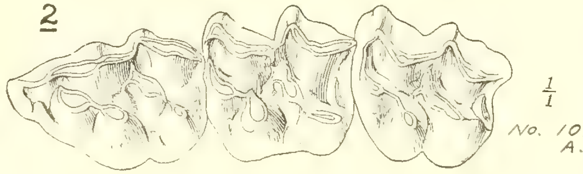
4



No. 14187d ref. A. M.

Merychippus isonesus primus

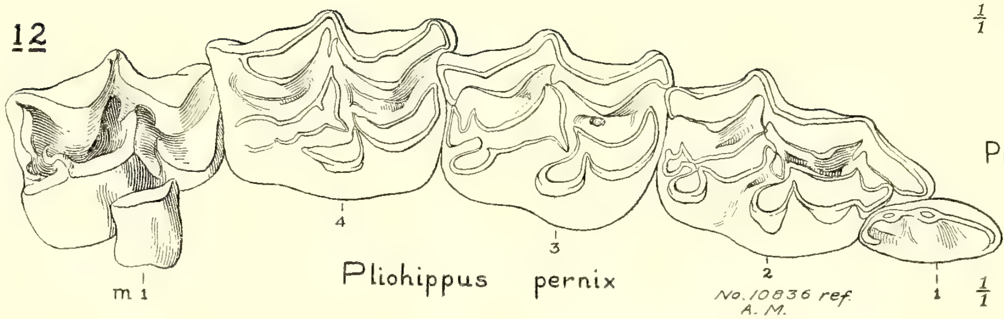
2



No. 10772 Type (Cast) A. M.

Parahippus cognatus

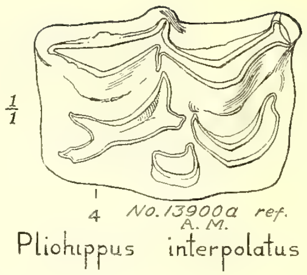
12



Pliohippus pernix

No. 10836 ref. A. M.

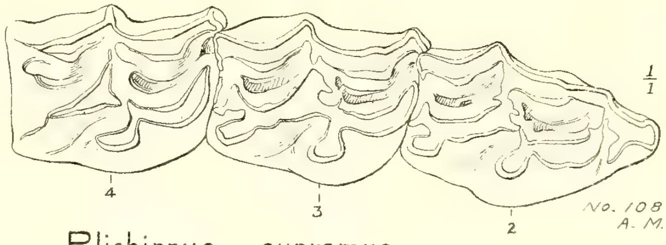
13



No. 13900a ref. A. M.

Pliohippus interpolatus

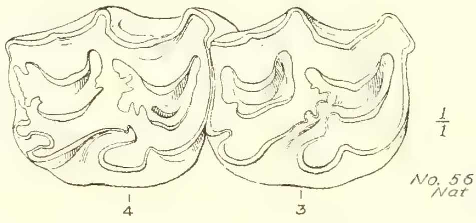
11



No. 10844 ref. A. M.

Pliohippus supremus

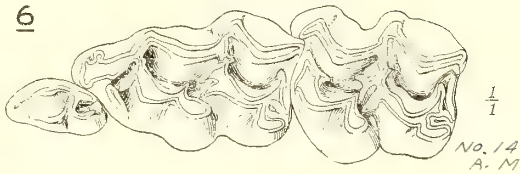
10



No. 569 Type Nat Mus.

Pliohippus mirabilis

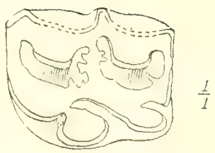
6



No. 14010 ref. A. M.

Merychippus

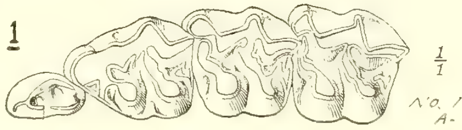
5



No. 9413 (rev) ref. A. M.

Merychippus paniensis

1



No. 12915 ref. A. M.

Parahippus pristinus

L. M. S.

PLATE 26.

FACE, *MERYCHIPPUS, PLIOHIPPUS.*

PLATE 26.

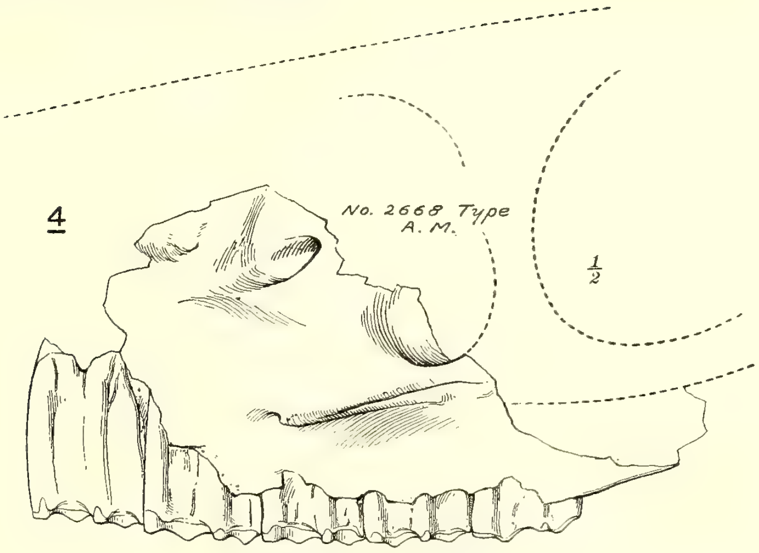
PREORBITAL FOSSÆ IN *MERYCHIPPUS* AND *PLIOHIPPUS*.

COMPARISON OF *MERYCHIPPUS CAMPESTRIS*, MIDDLE MIOCENE, AND THREE SPECIES OF *PLIOHIPPUS* FROM THE UPPER MIOCENE AND LOWER PLIOCENE.

All figures one-half natural size.

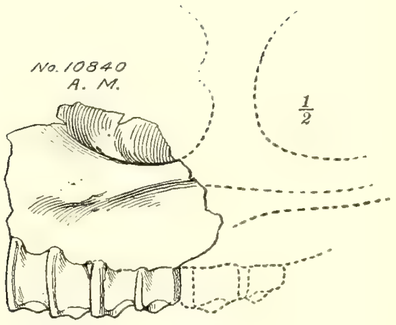
Pawnee Creek, Col.	Middle Miocene	1. *Merychippus campestris* Gidley, referred specimen, Am. Mus. 9459. Lachrymal and malar fossæ deep, well separated.
Little White River, So. Dak.	Lower Pliocene	2. *Pliohippus supremus* Leidy, referred specimen, Am. Mus. 10844.
" " " " "	" "	3. *Pliohippus mirabilis* Leidy, type, U. S. Nat. Mus. 569 (drawn from cast Am. Mus. 10840).
Republican River (*Teleoceras* quarry), Long Island, Nebr.	" "	4. *Pliohippus nobilis* Osborn, type, Am. Mus. 2668. Malar fossa distinct, deep; lachrymal fossa distinct anteriorly.

4



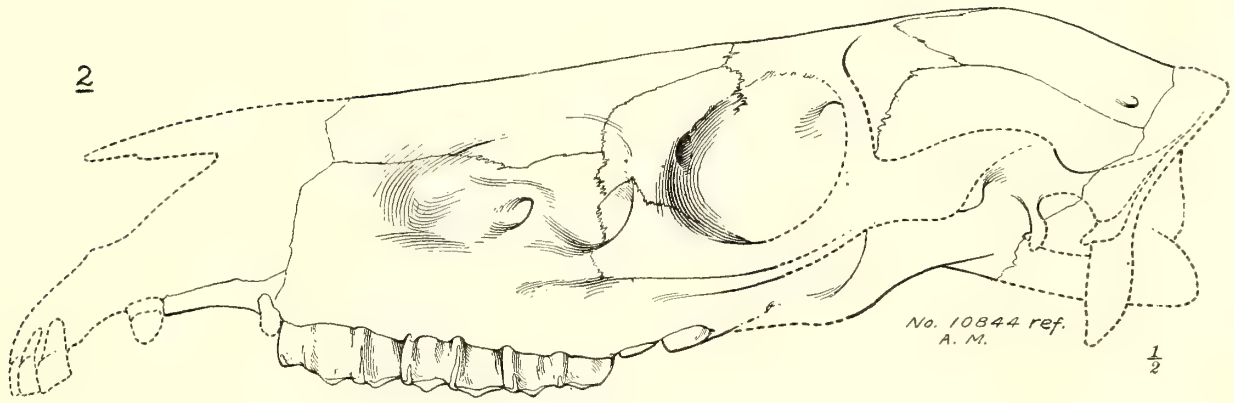
Pliohippus nobilis

3



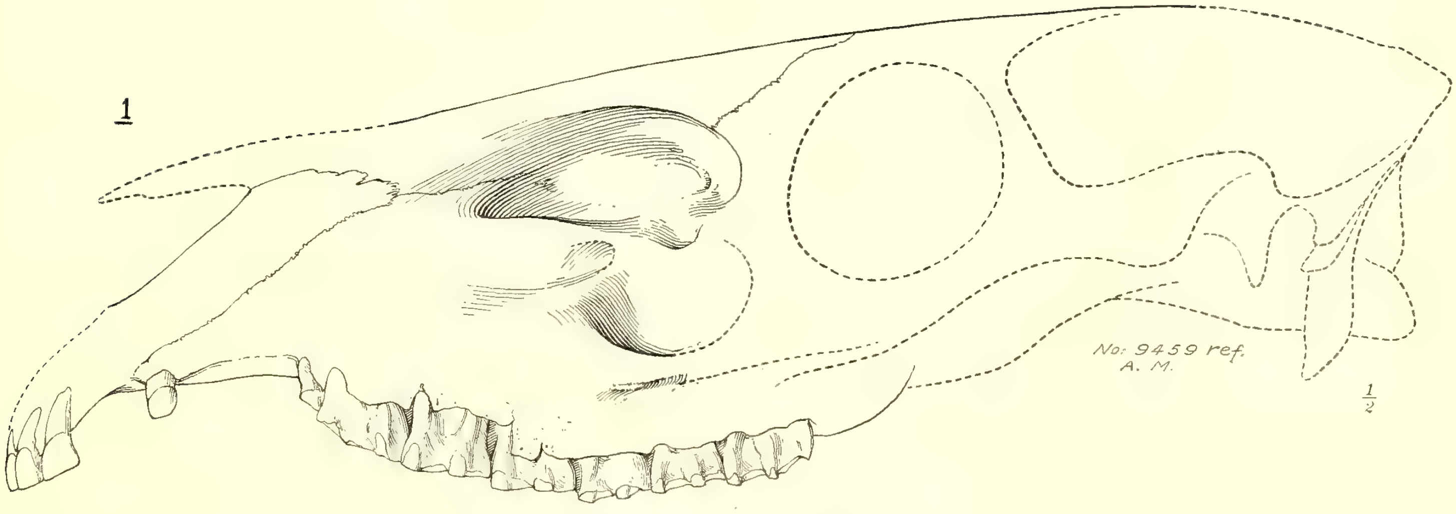
Pliohippus mirabilis

2



Pliohippus supremus

1



L. M. S.

Merychippus campestris

PLATE 27.

TYPE, *PLIOHIPPUS LULLIANUS.*

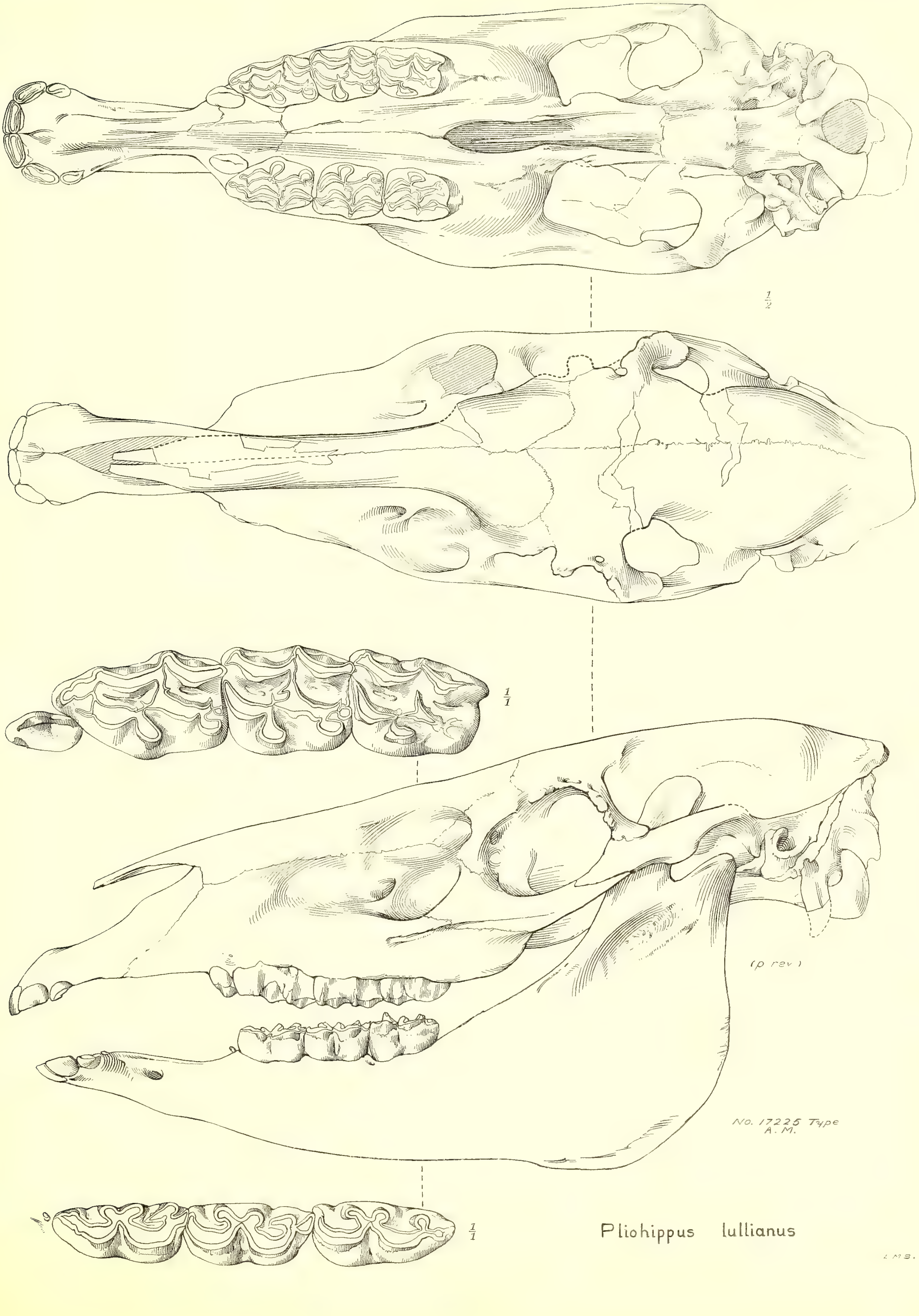
PLATE 27.

TYPE SKULL OF *PLIOHIPPUS LULLIANUS* TROXELL.

Teeth natural size. Skull and jaws one-half natural size.

This finely preserved skull of a young colt, Am. Mus. 17225, belonging to a species of the genus *Pliohippus*, was found near Mission on the Rosebud Indian Reservation in South Dakota, at a locality (Fig. 6) not far distant from the scene of the types found by Gidley. The geologic age is probably Lower Pliocene, similar to or slightly more recent than the Little White River levels.

Side view of skull, partly reversed in drawing.



Pliohippus lullianus

PLATE 28.

UPPER TEETH, *PLIOHIPPUS*.

PLATE 28.

UPPER TEETH OF *PLIOHIPPUS* FROM NEBRASKA, OREGON, AND TEXAS.

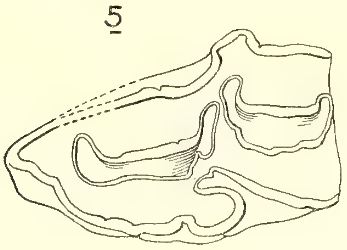
CHARACTERISTICS OF THE GENUS AND COMPARISON OF SPECIES FROM THE UPPER MIOCENE AND THE PLIOCENE.

All figures natural size.

Note the large cement lakes with relatively simple enamel borders, early and complete union of protocone to protoloph, and the tendency to later union with the metaloph. Characters are exaggerated in Pliocene species and lead into *Hippidium* of the South American Pleistocene.

Niobrara River, Nebr.	Lower Pliocene	1.	*Pliohippus pernix* Marsh, type, Yale Mus. 13007.
Rattlesnake, Ore.	?Pliocene	2.	*P. spectans* Cope, type, Am. Mus. 8183.
Snake Creek, Nebr.	Lower Pliocene	3.	*P. leidyanus* Osborn, referred specimen, Am. Mus. 14004.
Teleoceras quarry, Republican River, Long Island, Nebr.	“ “	4.	*P. nobilis* Osborn, type, Am. Mus. 2668.
Llano Estacado, Texas	Middle “	5.	*P. simplicidens* Cope, referred specimen, Am. Mus. 10624.

5

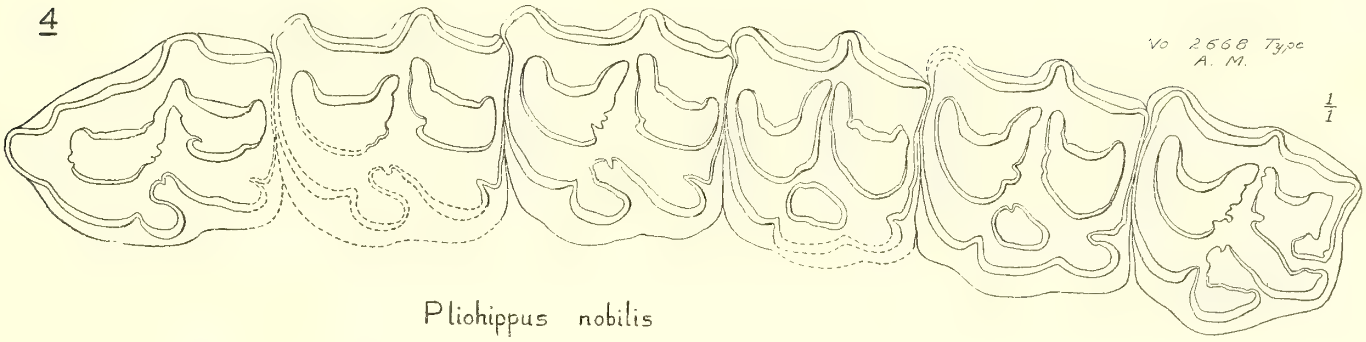


No 10624 ref
A.M.

1/1

Pliohippus simplicidens

4

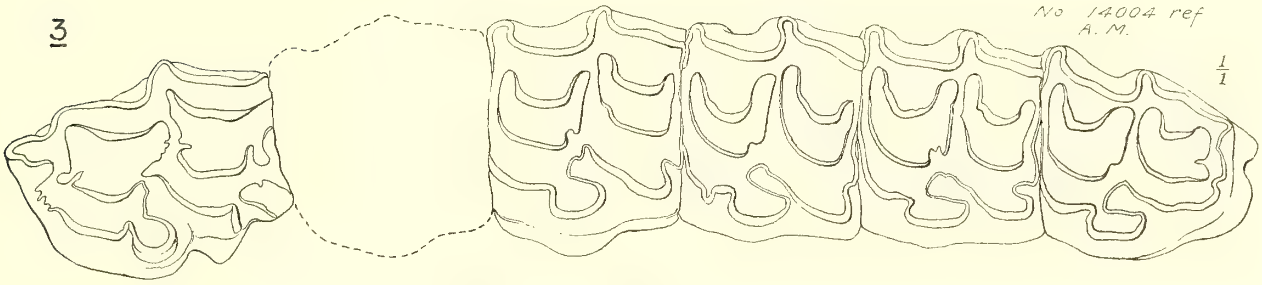


No 2668 Type
A. M.

1/1

Pliohippus nobilis

3

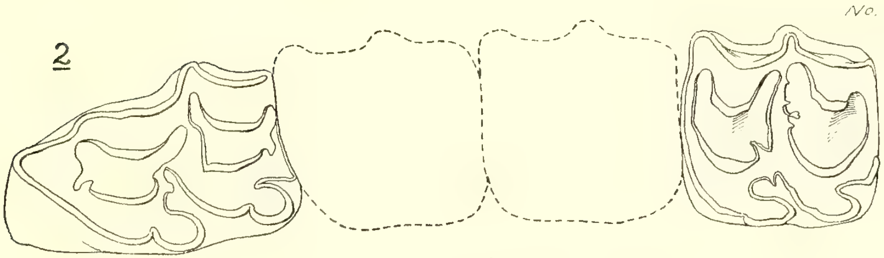


No 14004 ref
A. M.

1/1

Pliohippus leidyanus

2

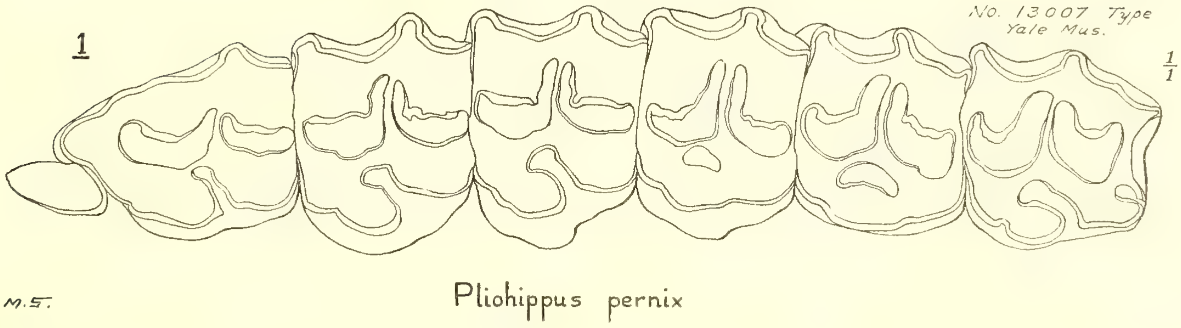


No. 8183 Type
A. M

1/1

Pliohippus spectans

1



No. 13007 Type
Yale Mus.

1/1

L.M.S.

Pliohippus pernix

PLATE 29.

TYPE, *PLIOHIPPUS LEIDYANUS* OSBORN.

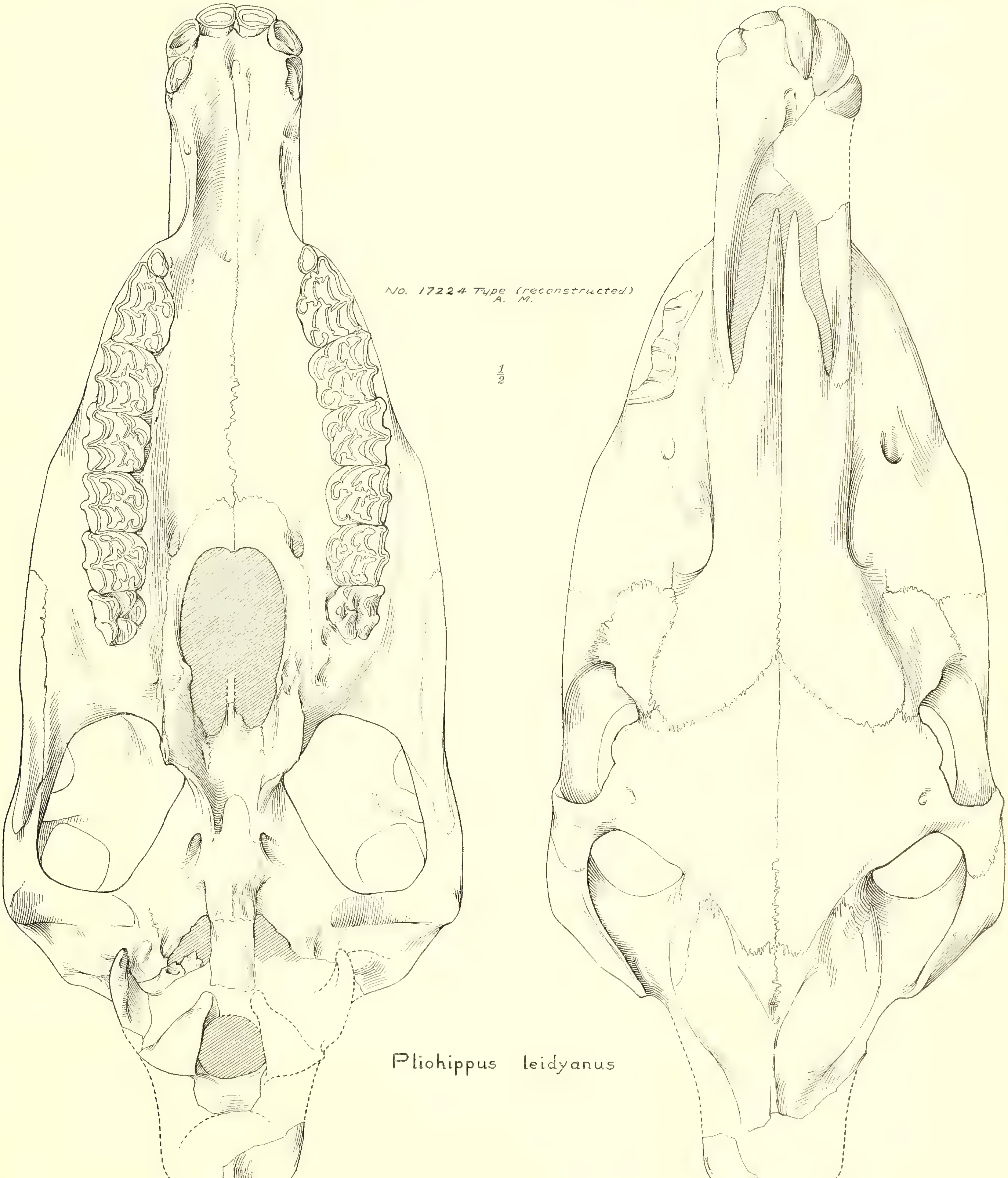
PLATE 29.

SKULL OF THE TYPE OF *PLIOHIPPUS LEIDYANUS* OSBORN.

One-half natural size.

Am. Mus. 17224, type. This is the best preserved adult skull referable to the genus *Pliohippus* which has thus far been discovered of Lower Pliocene age. It was found by Harold J. Cook in the upper levels of the Snake Creek formation in Sioux County, western Nebraska, during the winter of 1915–1916. The skull is obliquely crushed, and the drawings reproduced in Plates 29, 30 represent a very careful restoration, by measurement of the opposite sides, of the normal proportions of the skull, which belongs to a nearly adult female, about six years of age, the last grinding tooth, m^3, just coming into use.

The remaining characters of the skull of this type are shown on Plate 30.



Pliohippus leidyanus

PLATE 30.

TYPE, *PLIOHIPPUS LEIDYANUS* OSBORN.

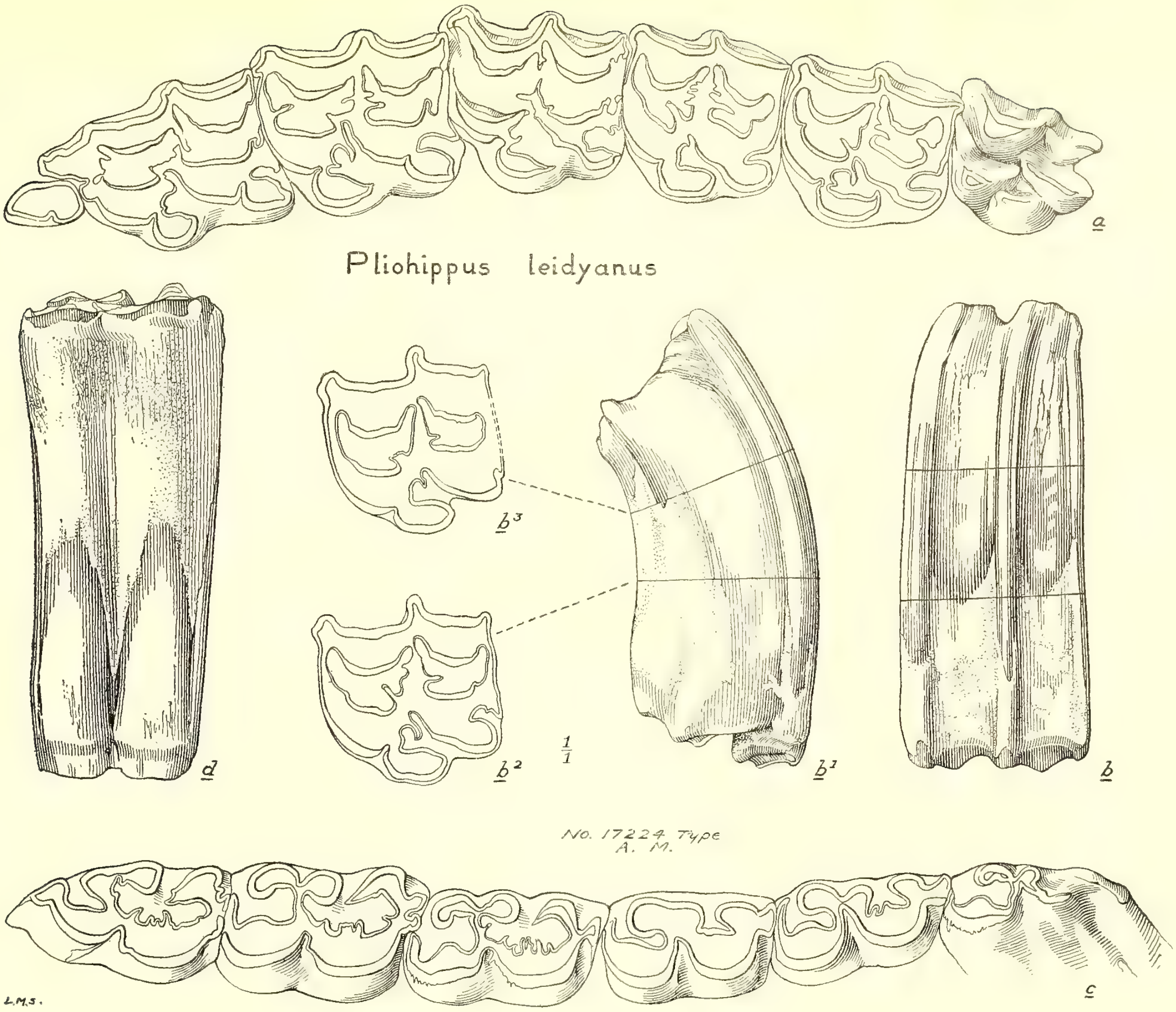
PLATE 30.

SKULL AND TEETH OF THE TYPE OF *PLIOHIPPUS LEIDYANUS* OSBORN.

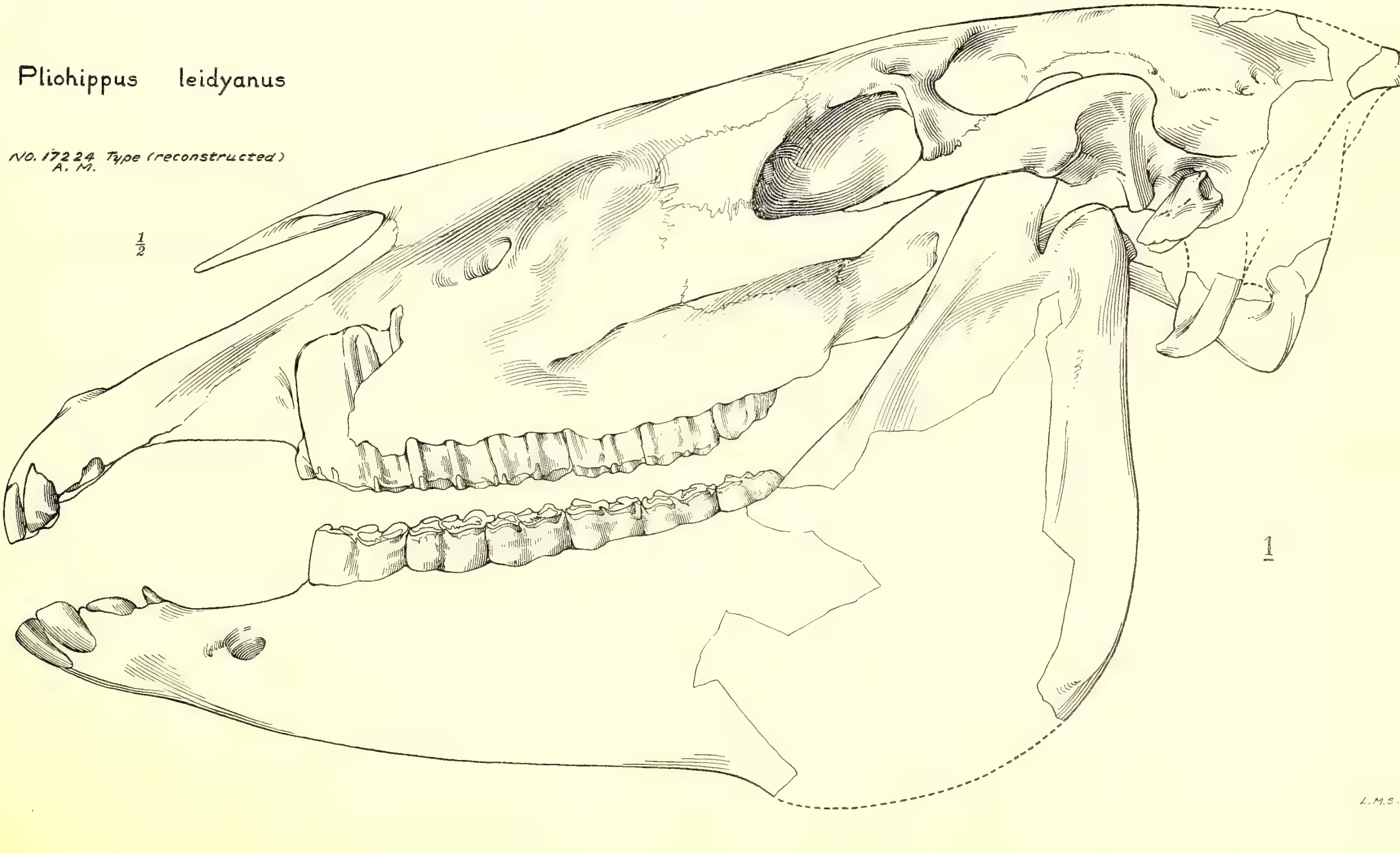
Continued from Plate 29.

Teeth natural size. Skull one-half natural size.

Snake Creek, Sioux Co., Nebr.	Lower Pliocene	1. *Pliohippus leidyanus* Osborn, Am. Mus. 17224. Superior and inferior grinding teeth of the type; *a*, crown views of upper dentition, *c*, crown view of lower dentition; *d*, external view of p_4; *b*, external view of p^4, b^1, anterior view, b^2, section of the middle portion of the crown, b^3, section of lower portion of the crown.
		2. *Pliohippus leidyanus* Osborn, Amer. Mus. 17224, skull and jaws of the type (partly reconstructed in drawing).


a
Pliohippus leidyanus
d
b³
b²
1/1
b¹
b
No. 17224 Type
A. M.
c
L.M.S.

2


Pliohippus leidyanus
No. 17224 Type (reconstructed)
A. M.
1/2
L.M.S.

1

PLATE 31.

TEETH, *PLIOHIPPUS*, *HIPPARION*.

PLATE 31.

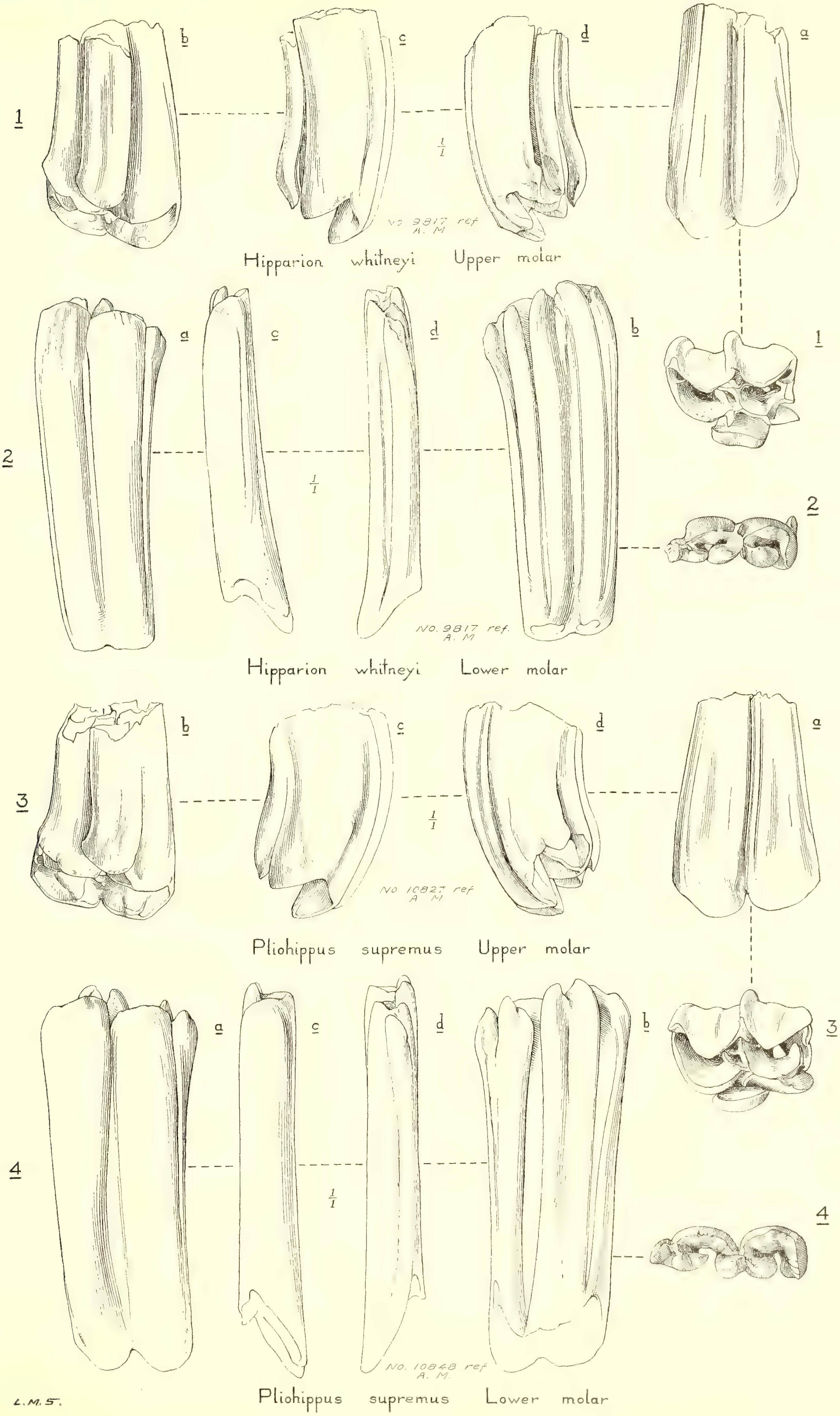
PLIOHIPPUS AND *HIPPARION* FROM SOUTH DAKOTA AND NEBRASKA.

UPPER AND LOWER MOLARS, UNWORN, WITHOUT CEMENT, TO SHOW PARALLELISM AND DIFFERENCES IN CONSTRUCTION OF THE CROWNS.

All figures natural size.

Note the curvature of the upper molar in *Pliohippus* (3, *c*, *d*) as stronger than in *Hipparion* (1, *c*, *d*); also the separation of the protocone to base of tooth in *Hipparion* (1, *b*, *c*, *d*), prominence of the parastylid in *Hipparion* (2, *a*, *c*), and the complete separation of metastylid from metaconid (2, *b*).

Little White River, S. D.	Lower Pliocene	1, 2.	*Hipparion whitneyi* Gidley, referred specimen, Am. Mus. 9817. 1, Upper molar; *a*, external, *b*, internal, *c*, anterior, *d*, posterior, and, 1, crown views; 2, upper molar, same views.
Snake Creek, Sioux Co., Nebr.	" "	3.	*Pliohippus supremus* Leidy, referred specimen, Am. Mus. 10827. Upper molar. Same views as in figs. 1, 2.
" " " "		4.	*Pliohippus supremus* Leidy, referred specimen, Am. Mus. 10848. Lower molar. Same views as in figs. 1, 2.



Hipparion whitneyi Upper molar

Hipparion whitneyi Lower molar

Pliohippus supremus Upper molar

Pliohippus supremus Lower molar

PLATE 32.

FACE, *HIPPARION*.

PLATE 32.

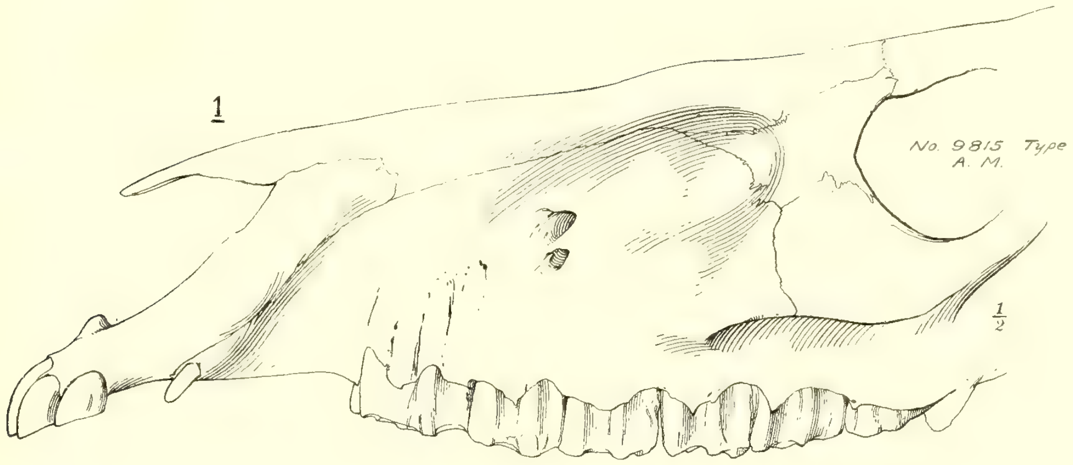
PREORBITAL FOSSÆ IN *HIPPARION* FROM SOUTH DAKOTA AND TEXAS.

COMPARISON OF ANTERIOR PORTION OF SKULL IN THREE AMERICAN SPECIES.

All figures one-half natural size.

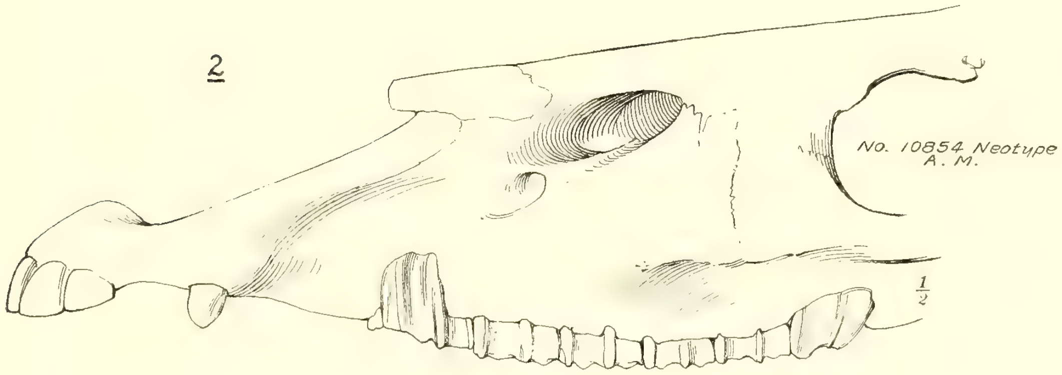
Little White River, So. Dak.	Lower Pliocene	1. *Hipparion whitneyi* Gidley, type, Am. Mus. 9815. Lachrymal fossa shallow, broad; no malar fossa.
Llano Estacado, Texas	" "	2. *Hipparion lenticulare* Cope, neotype (Gidley), Am. Mus. 10854. Lachrymal fossa deep, restricted, anterior in position; no malar fossa.
Little White River, So. Dak.	" "	3. *Hipparion gratum* Leidy, neotype (Gidley), Am. Mus. 10863 (reversed in drawing). Lachrymal fossa shallow, restricted, anterior in position; malar fossa vestigial.

1



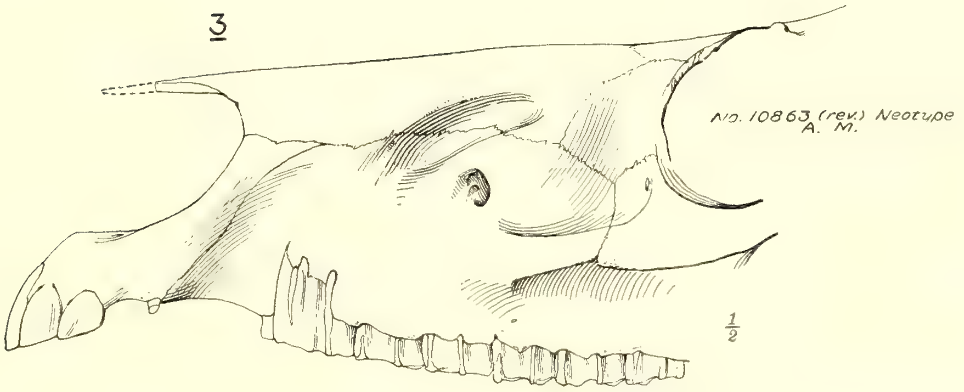
Hipparion whitneyi

2



Hipparion lenticulare

3



L.M.S

Hipparion gratum

PLATE 33.

TEETH, *PLIOHIPPUS*, *HIPPARION*.

PLATE 33.

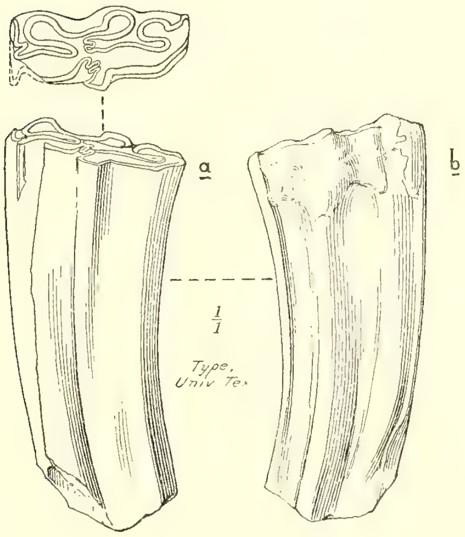
PLIOHIPPUS AND *HIPPARION* FROM THE LOWER PLIOCENE OF NORTHERN TEXAS.

All figures natural size.

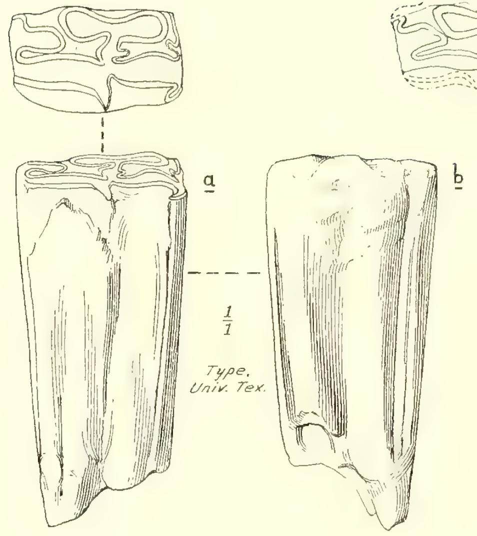
Type specimens from the Clarendon formation, Texas, described by Professor Cope in 1892–3. Originals loaned for study from the collection of the University of Texas through the courtesy of Professor F. W. Simonds.

Palo Duro Cañon, Texas	Lower Pliocene	1, 2, 3. *Hipparion eurystyle* Cope, Univ. of Texas coll. Lower molar teeth. These are the teeth figured by Cope as paratypes. See text Fig. 149, 7–8b. 1, Crown view, *a*, outer view, *b*, inner view; 2, crown view, *a*, outer view, *b*, inner view; 3, crown view; 4, crown view, *b*, inner view.
“ “ “	“ “ “	4. *H. eurystyle* Cope, type, Univ. of Texas coll. Lower molar tooth. This is the tooth figured by Cope as his type. See text Fig. 149, 6, 6*a*.
“ “	“ “ “	5. *Hipparion lenticulare* Cope, Univ. of Texas coll. Right upper molar of type. 5, crown view, *a*, outer view, *d*, posterior view. Figured by Cope 1889. See text Fig. 147, 1.
“ “	“ “ “	6, 7. *Hipparion lenticulare* Cope, Univ. of Tex. coll., left upper molar of type. 6, Crown view, *d*, posterior, *a*, external view. Figured by Cope, 1889. See text Fig. 147, 2. 7, anterior view.
Mt. Blanco, “	Middle “	8. *Pliohippus minutus* Cope (= *Equus phlægon* Hay), type lower molar, Univ. of Tex. Coll. 8, Crown view, *a*, external view, *b*, inner view.

1



2



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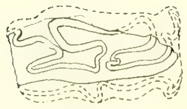

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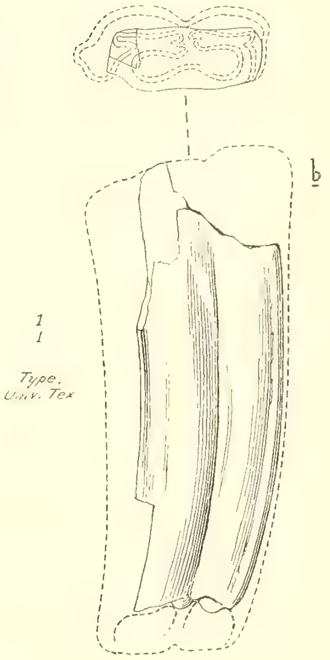
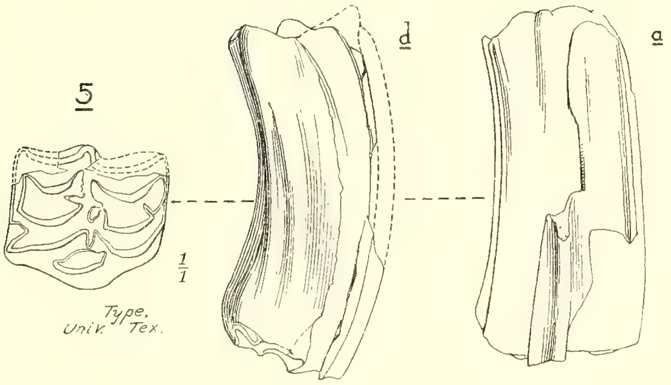


Hipparion eurystyle

5



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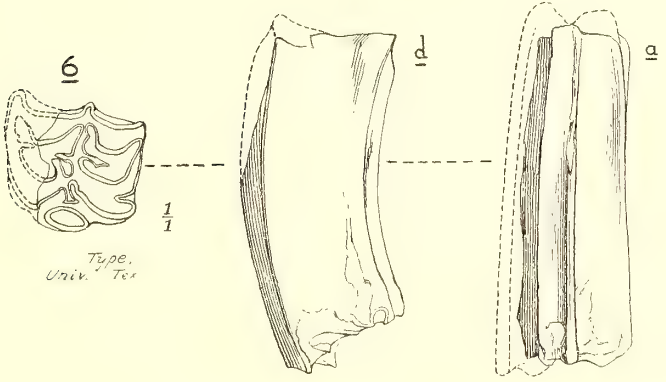

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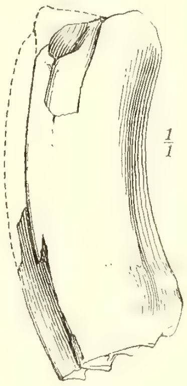
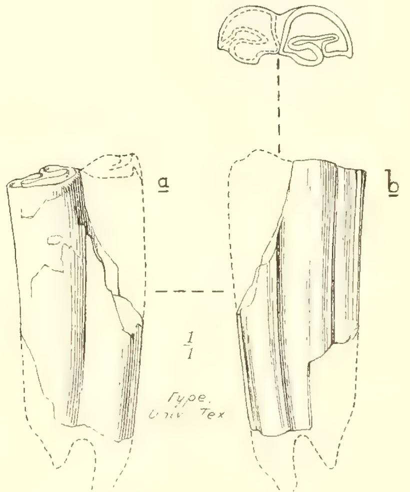


Hipparion lenticulare

8



Pliohippus minutus

L.M.S.

PLATE 34.

MILK TEETH, *MERYCHIPPUS, PROTOHIPPUS HIPPARION.*

PLATE 34.

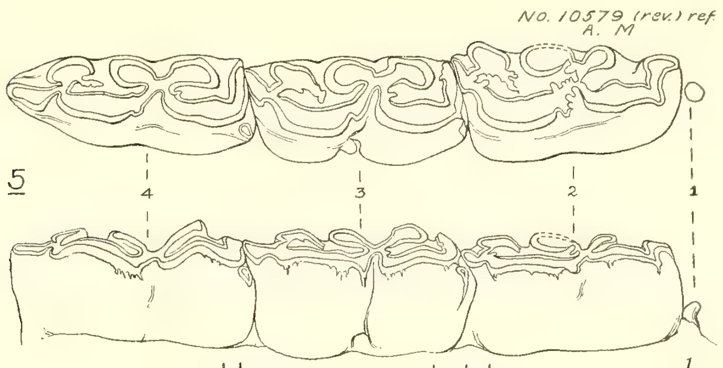
LOWER MILK TEETH OF MIOCENE *MERYCHIPPUS*, *PROTOHIPPUS*, AND *HIPPARION*.

All figures natural size.

Note the lower, broader crowns in *Merychippus*, and the wide separation of metaconid from metastylid in *Hipparion*. The pattern of the milk teeth in each genus is characteristically like the permanent dentition. Fig. 1 no cement, Fig. 2 a thin coat, Figs. 3–5 heavily cemented.

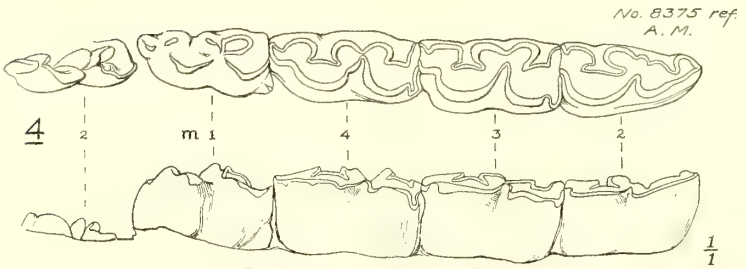
Pawnee Creek, Col.	Middle Miocene	1. *Merychippus paniensis* Cope, referred specimen, Am. Mus. 8290, unworn milk premolars (reversed in drawing).
" " "	" "	2. *M. paniensis* Cope, referred specimen, Am. Mus. 9403, milk premolars, well worn.
Upper Pawnee Creek, Col.	Lower Pliocene	3. *Protohippus proplacidus* Osborn, type, Am. Mus. 9115b, milk premolars, little worn.
Little White River, So. Dak.	" "	4. *P. placidus* Leidy, referred specimen, Am. Mus. 8375, milk teeth, moderately worn.
" " "	" "	5. *Hipparion occidentale* Leidy, referred specimen, Am. Mus. 10579, milk teeth, moderately worn (reversed in drawing).

5



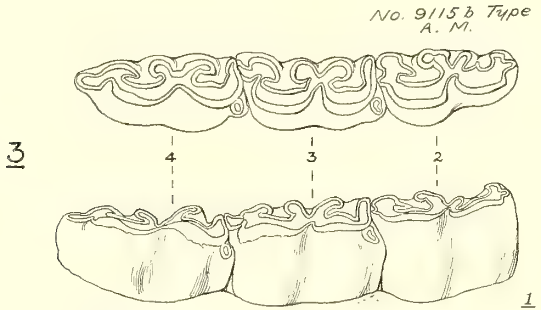
Hipparion occidentale

4



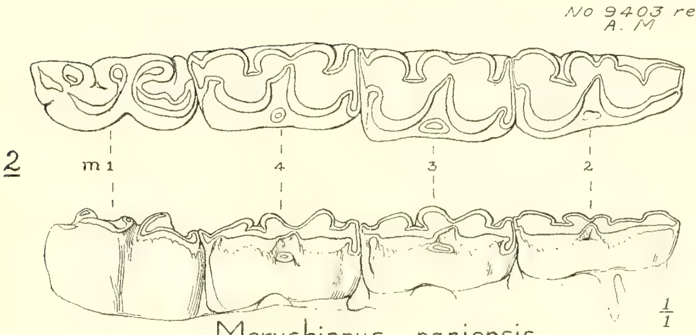
Protohippus placidus

3



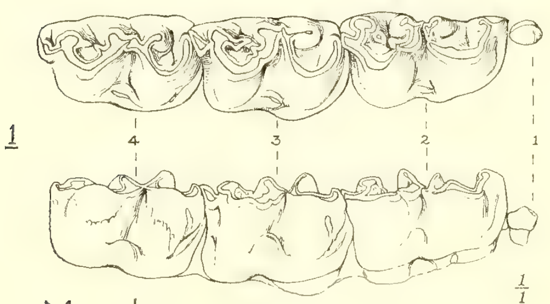
Protohippus proplacidus

2



Merychippus paniensis

1



Merychippus paniensis

L.M.S.

PLATE 35.

SKULL AND TEETH, *HYPOHIPPUS.*

PLATE 35.

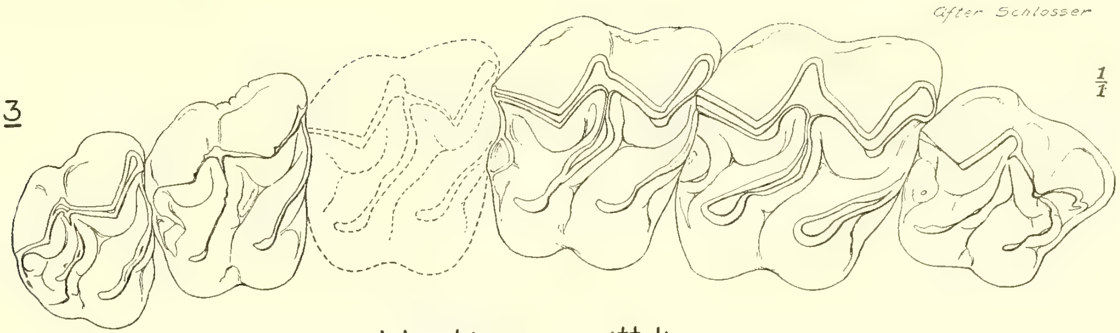
SKULL AND UPPER TEETH OF *HYPOHIPPUS.*

GENERIC CHARACTERS AND COMPARISON OF THREE SPECIES.

All figures natural size.

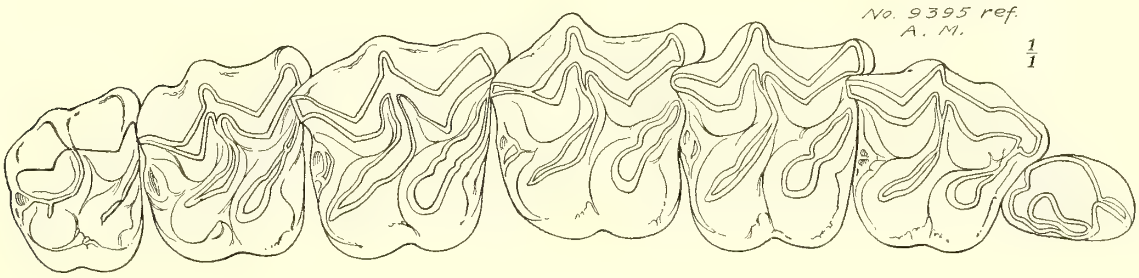
Snake Creek, Sioux Co., Nebr.	Lower Pliocene	1. *Hypohippus affinis* Leidy, referred specimen, Am. Mus. 14043, upper teeth, moderately worn, probably of two individuals.
Pawnee Creek, Col.	Middle Miocene	2. *H. osborni* Gidley, referred specimen, Am. Mus. 9395, upper teeth, little worn.
China	Pliocene	3. *H. zitteli* Schlosser (Munich Mus.), upper teeth, unworn, from different individuals (drawn from Schlosser's figure).
Pawnee Creek, Col.	Middle Miocene	4. *H. osborni* Gidley, type, Amer. Mus. 9407, side view of skull (partly reversed in drawing).

3



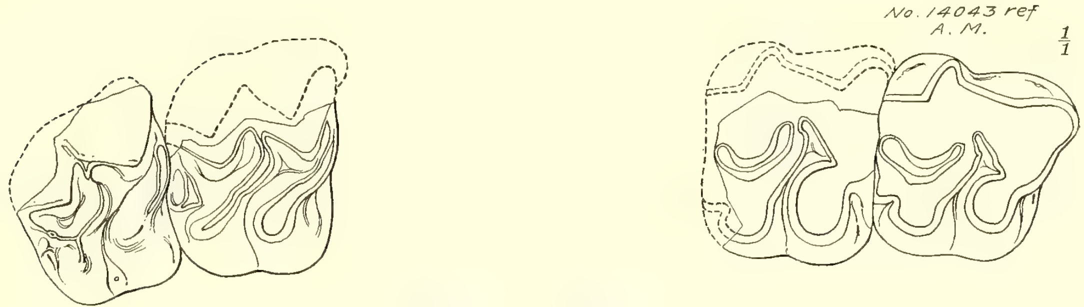
Hypohippus zitteli

2



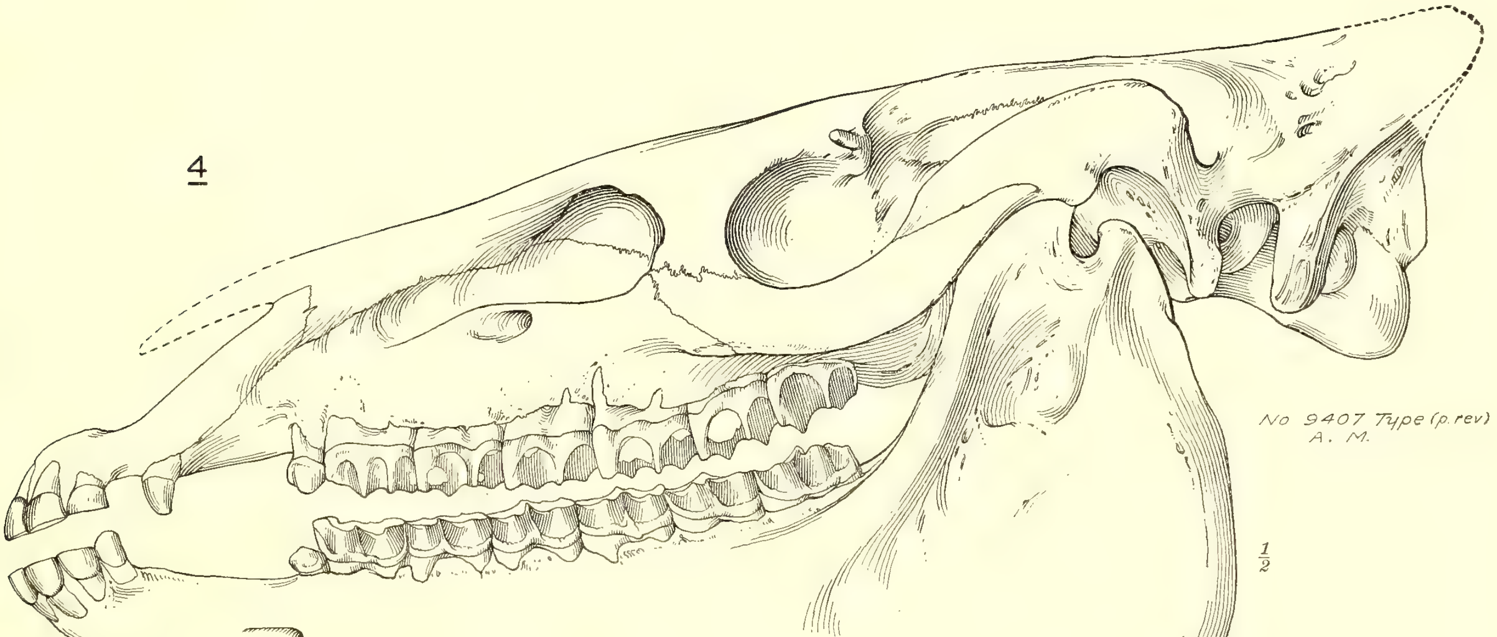
Hypohippus osborni

1



Hypohippus affinis

4



L.M.S.

Hypohippus osborni

PLATE 36.

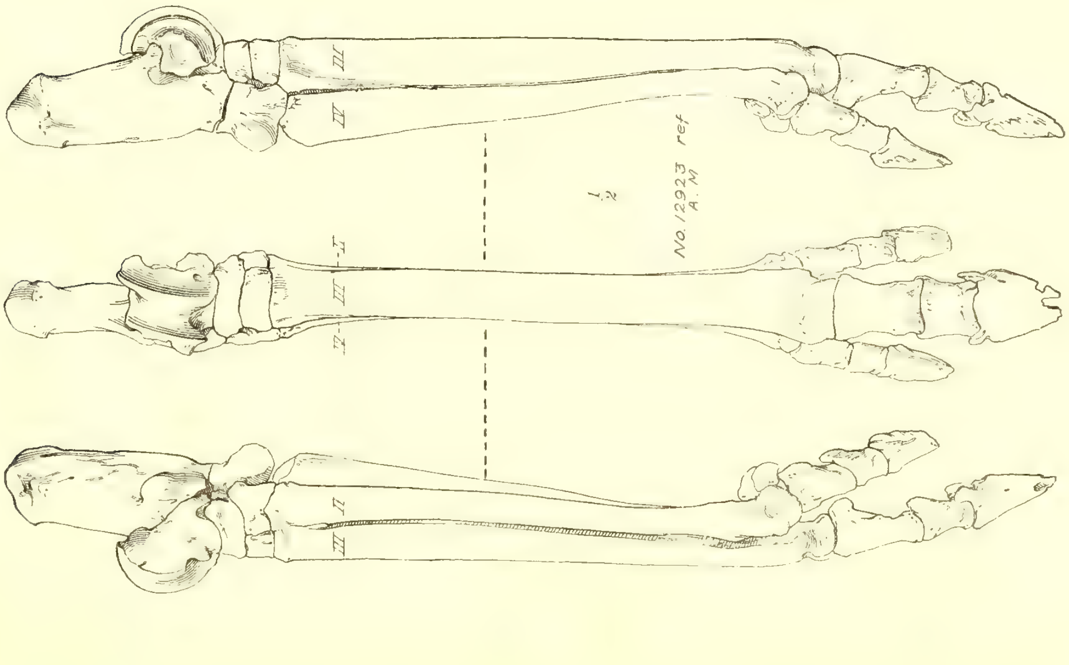
HIND FEET, *PARAHIPPUS*.

PLATE 36.

HIND FEET OF *PARAHIPPUS* FROM THE LOWER MIOCENE.

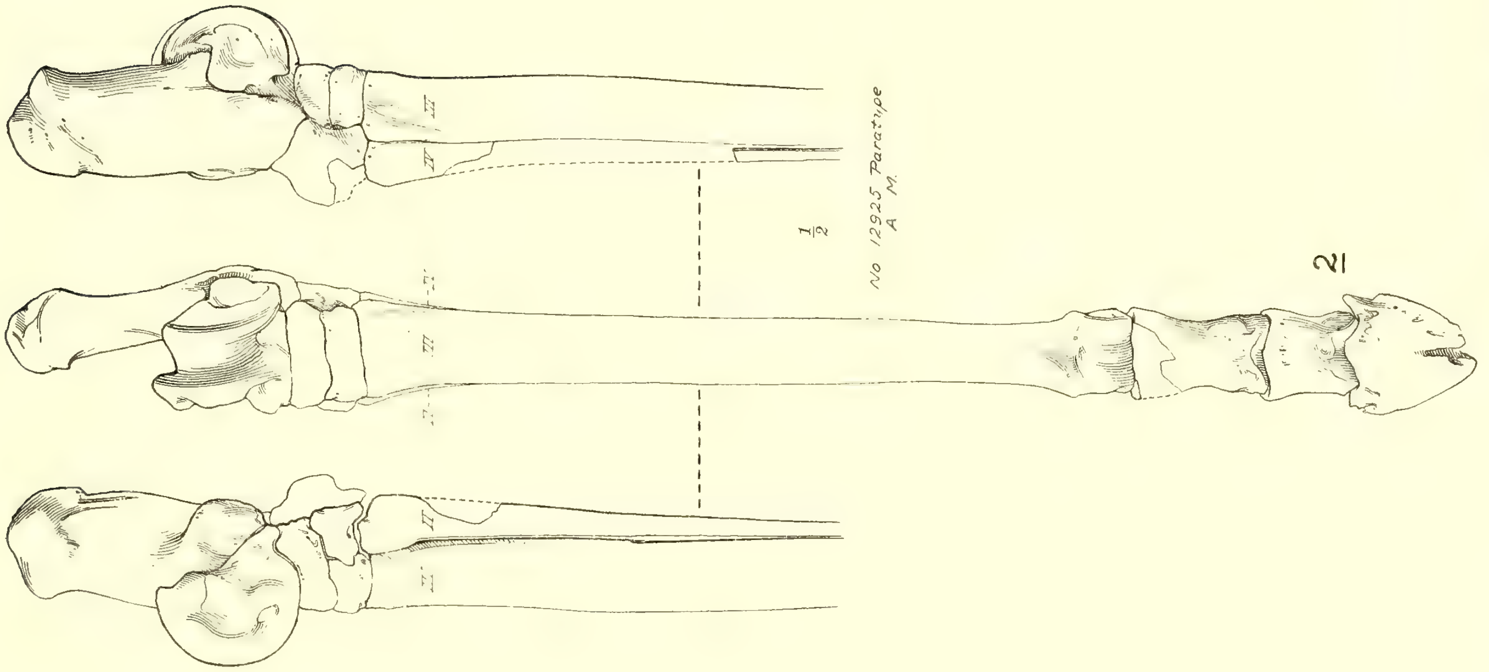
All figures one-half natural size.

Lower Rosebud, Porcupine Creek, Pine Ridge, So. Dak.	Lower Miocene	1. *Parahippus pristinus* Osborn, referred specimen, Am. Mus. 12923, hind foot.
Upper Rosebud	" "	2, 3. *Parahippus coloradensis præcurrens* Osborn, paratype, Am. Mus. 12925, (2) hind foot, (3) fore foot. The limbs are slender and the feet are long, with the lateral digits greatly reduced. Associated with these feet is the paratype lower jaw fragment with premolars, parts of tibia and radius.



1

Parahippus pristinus



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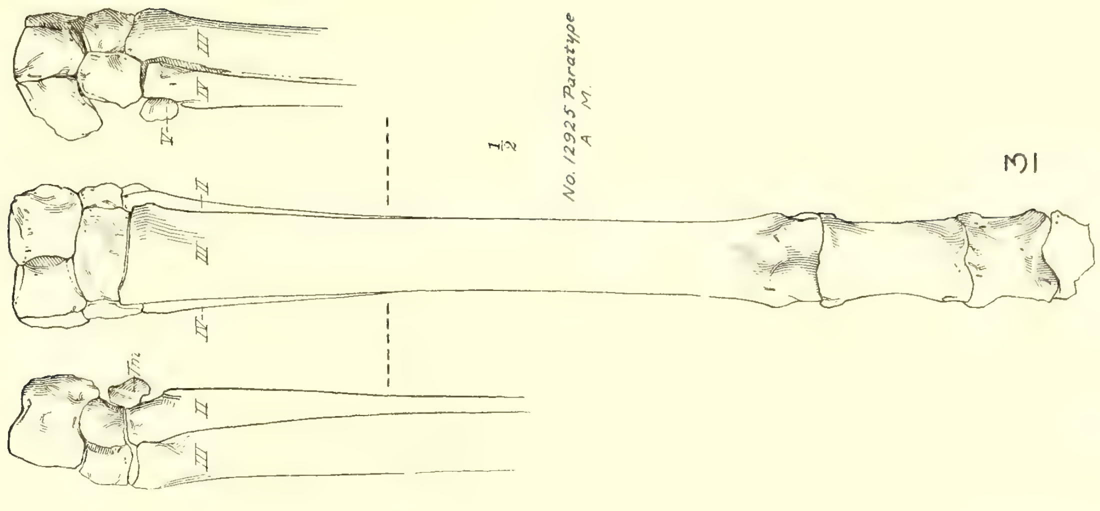


3

Parahippus coloradensis praecurrens

PLATE 37.

FEET, *PARAHIPPUS.*

PLATE 37.

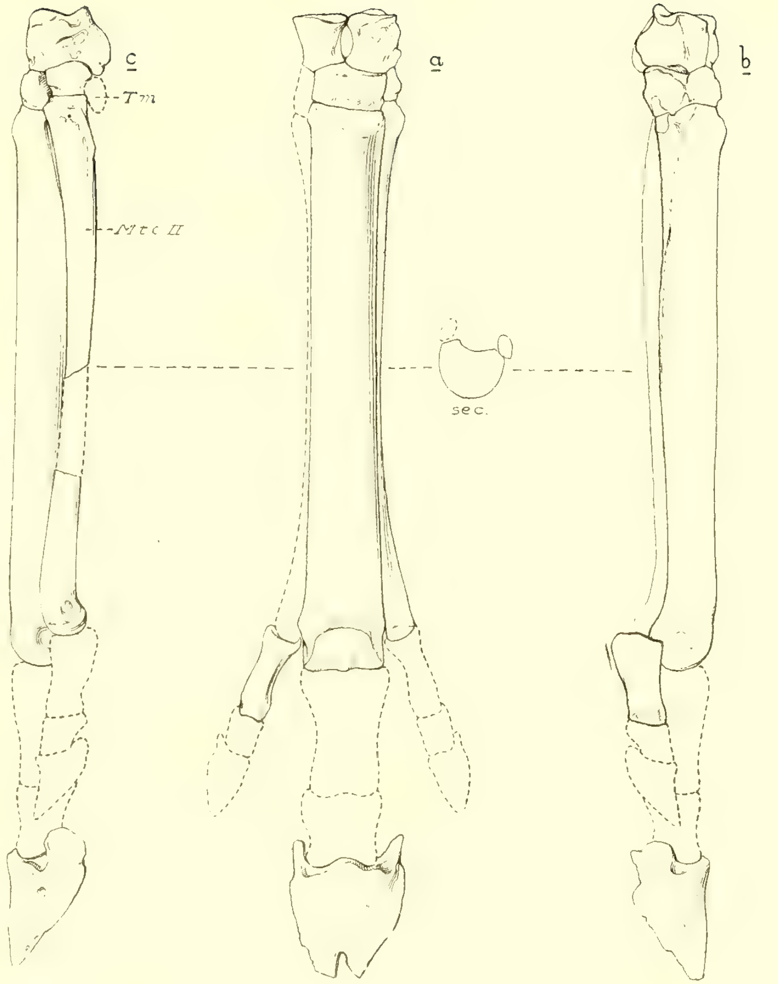
FORE AND HIND FEET OF *PARAHIPPUS* FROM SHEEP CREEK, NEBRASKA.

THE FEET ARE PRACTICALLY INDISTINGUISHABLE FROM THOSE OF THE SPECIES OF *MERYCHIPPUS* (*M. ISONESUS TERTIUS*, *M. ISONESUS QUARTUS*) FOUND IN THE SAME BEDS.

All figures one-half natural size.

Sheep Creek, Sioux Co., Nebr.	Middle Miocene	1, 2.	*Parahippus avus,* referred specimen, Am. Mus. Cope Coll. 14182. 1, Right fore foot, *a,* front view, *b,* outer, and *c,* inner views; 2, left hind foot, same views. Lower teeth of the same specimen, Plate 8, Fig. 6; upper teeth, Plate 9, Fig. 4.

1



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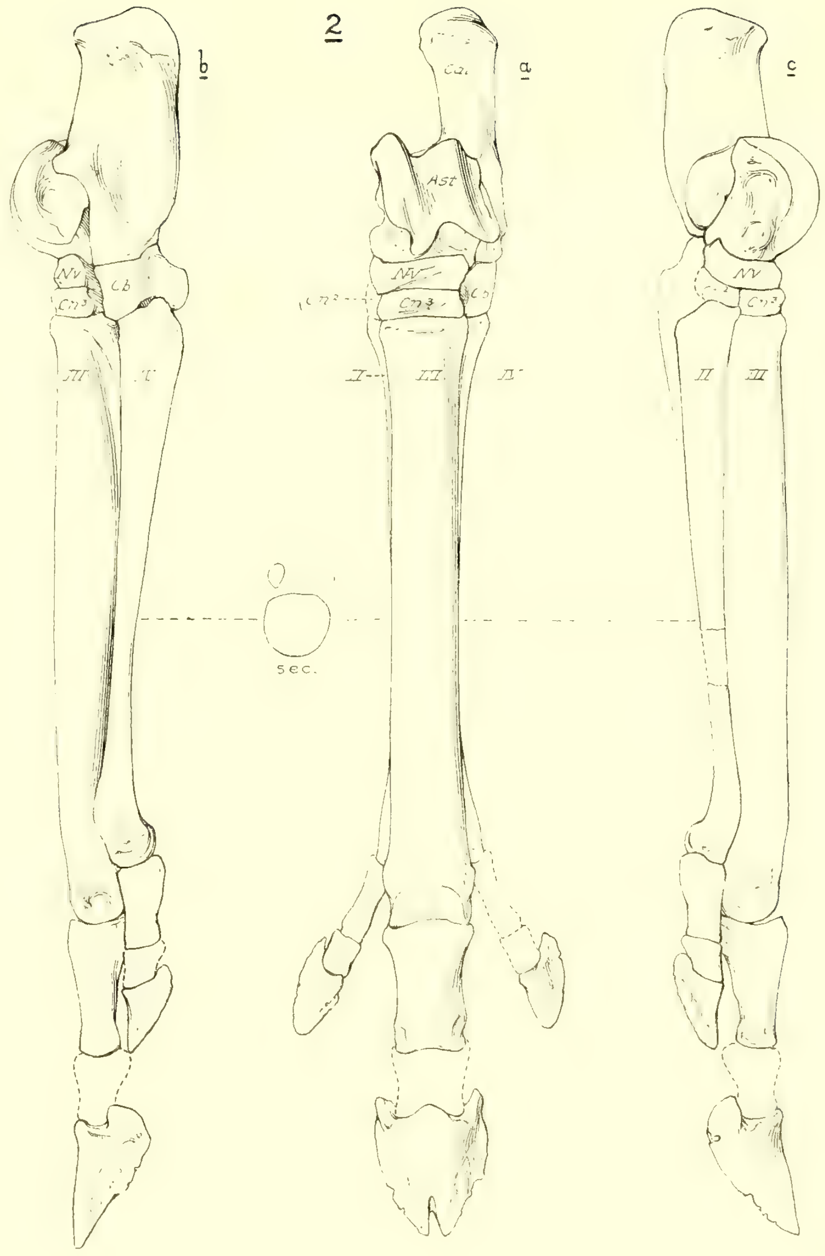


1/2

No. 14182 ref. A. M.

Parahippus

L M S

PLATE 38.

SKELETON, *PARAHIPPUS*.

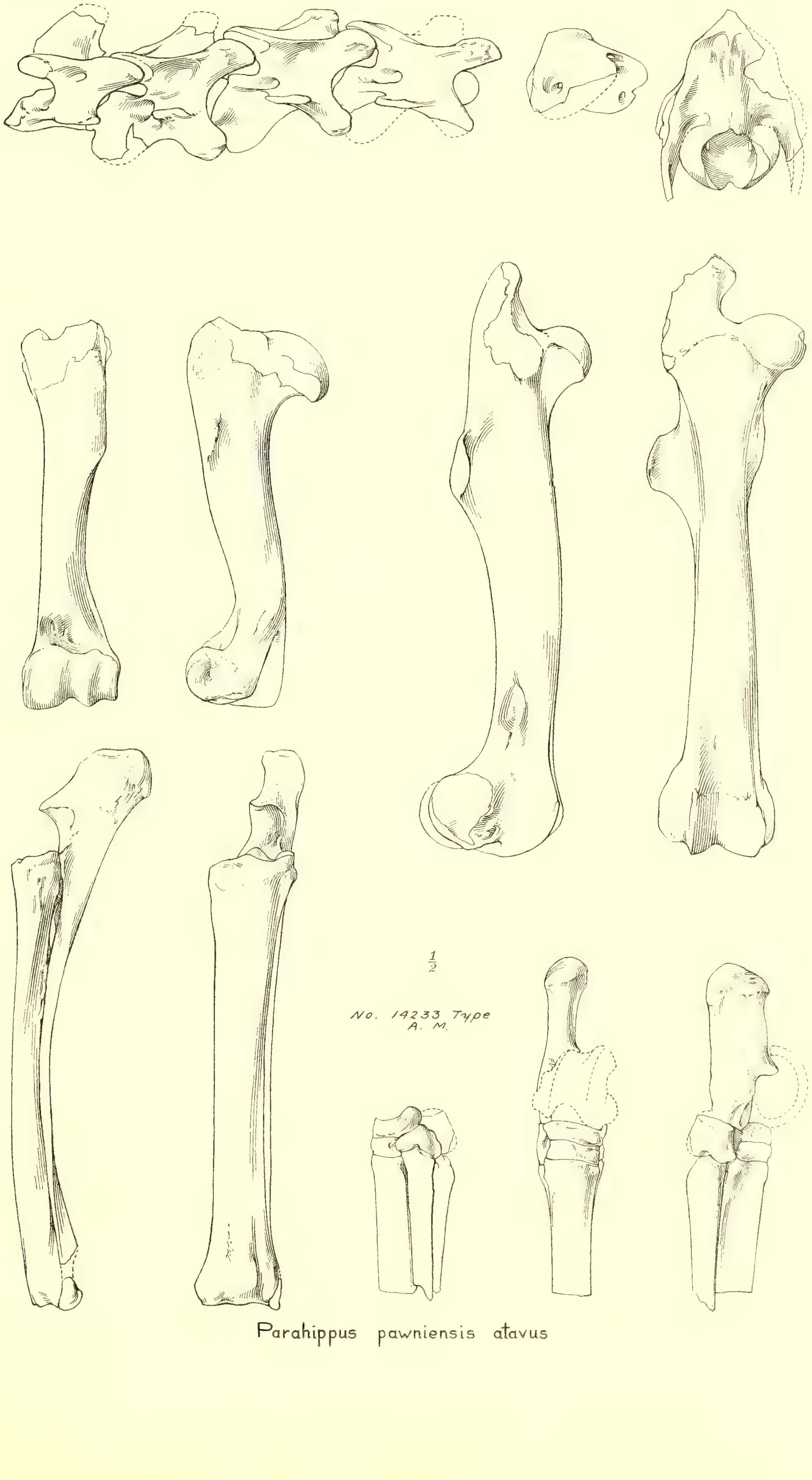
PLATE 38.

TYPE SKELETON OF *PARAHIPPUS PAWNIENSIS ATAVUS* OSBORN.

All figures one-half natural size.

This animal is selected as the type of a subspecies with the idea that it may be ancestral to the species *P. pawniensis* Gidley, Middle Miocene. Note the separate ulna, characteristic of *Parahippus.*

Upper Harrison, near Agate, Sioux Co., Nebr.	Lower Miocene	*Parahippus pawniensis atavus* Osborn, type, Am. Mus. 14233, occiput, portion of atlas, four cervical vertebræ, humerus, ulna, radius, complete fore foot, femur, portions of tarsus. See also carpus of same type skeleton figured in Plate 39, Fig. 9.



Parahippus pawniensis atavus

PLATE 39.

CARPUS, MIOCENE HORSES.

PLATE 39.

REDUCTION OF CARPUS IN MIOCENE EQUIDÆ.

DIAGRAMS SHOWING RELATIONS OF CARPAL BONES TO MEDIAN METATARSAL, AND PROGRESSIVE REDUCTION OF THE VESTIGIAL FIFTH DIGIT.

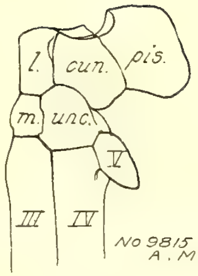
All figures one-half natural size.

	1– 3	Outer side of carpus
	8–10	“ “ “ “
	15–17	“ “ “ “
	4– 7	Inner “ “ “
	11–14	“ “ “ “
	18–20	“ “ “ “
Middle Oligocene	15, 18	*Mesohippus* (*M. bairdii*, referred specimen, Am. Mus. 9777). Unciform facet on Mtc. III vertical, giving ulna no support on cannon bone. Fifth digit a short splint.
Upper Oligocene	16, 19	*Miohippus* (*M. gidleyi*, referred specimen, Am. Mus. 1195). Unciform facet slightly oblique.
Uppermost Oligocene	17, 20	*Kalobatippus* (*K. agatensis*, type, Am. Mus. 14211). Unciform facet somewhat oblique; trapezium more lateral in position.
Middle Miocene	8, 11	*Hypohippus* (*H. osborni*, type, Am. Mus. 9407). Unciform facet on Mtc. V greatly reduced; Mtc. II giving some support to magnum.
Middle Miocene	9, 10, 12, 13, 14	*Parahippus* (9, 13 *P. pawniensis atavus*, type,[1] Am. Mus. 14233; 10, 12 *P. tyleri*, referred specimen, Am. Mus. 13767; 14 *Parahippus*, Am. Mus. 14182). Unciform facet on Mtc. III oblique, fifth metacarpal a very short splint or nodule, trapezium lateral in this and following genera.
“ “	2, 6	*Merychippus* (2 *M. isonesus primus*, referred specimen, Am. Mus. 14179; 6 *M. eoplacidus*, type, Am. Mus. 9397). Unciform facet on cannon bone oblique, fifth metacarpal a small nodular rudiment.
Lower Pliocene	1, 4, 5	*Hipparion* (1, 4 *H. whitneyi* Gidley, type, Am. Mus. 9815; 5 *H. gracile*, drawing from Gaudry's figure). Unciform facet on cannon bone more horizontal, Mtc. V a small nodule, magnum facet on Mtc. II oblique or in some species reduced and vertical, a condition that might lead to trapezoid acquiring a footing upon the cannon bone.
Lower Pliocene	3, 7	*Pliohippus ? spec.*, referred specimen, Am. Mus. 10690. Unciform facet on Mtc. III more horizontal, fifth metacarpal a vestigial nodule.

---

[1] See also parts of type skeleton, Am. Mus. 14233, Plate 38.

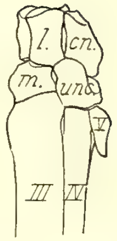
1



No 9815 Type A. M.

Hipparion
H. whitneyi

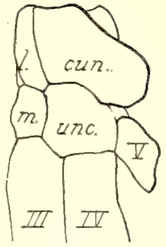
2



No. 14179 ref. A. M.

Merychippus
M. isonesus primus

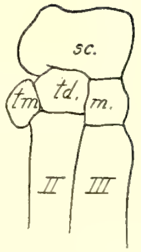
3



No. 10690 ref. A. M.

Pliohippus

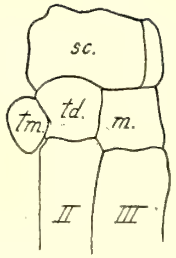
4



No. 9815 Type A. M.

Hipparion
H. whitneyi

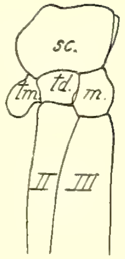
5



After Gaudry.

Hipparion
H. gracile

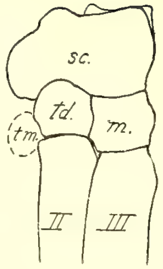
6



No. 9397 Type A. M.

Merychippus
M. eoplacidus

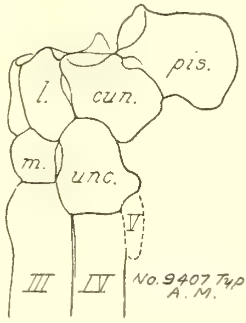
7



No. 10690 ref. A. M.

Pliohippus

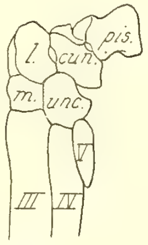
8



No. 9407 Type A. M.

Hypohippus
H. osborni

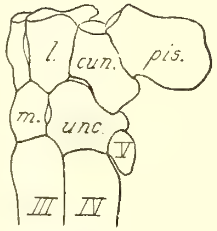
9



No. 14233 Type A. M.

Parahippus
P. pawniensis atavus

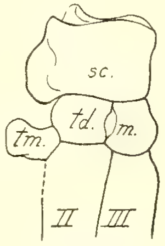
10



No. 13767 ref. A. M.

Parahippus
P. tyleri

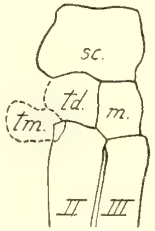
11



No. 9407 Type A. M.

Hypohippus
H. osborni

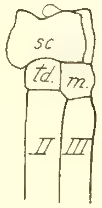
12



No. 13767 ref. A. M.

Parahippus
P tyleri

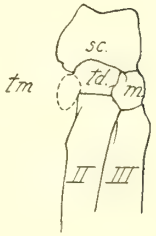
13



No. 14233 Type A. M.

Parahippus
P. pawniensis atavus

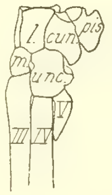
14



No. 14182 ref. A. M.

Parahippus

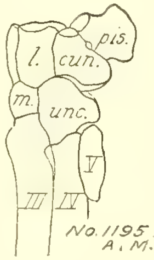
15



No. 9777 ref. A. M.

Mesohippus
M. bairdii

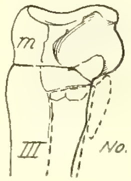
16



No. 1195 ref. A. M.

Miohippus
M. gidleyi

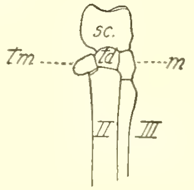
17



No. 14211 Type A. M.

Kalobatippus
K. agatensis

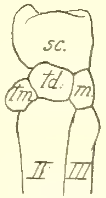
18



No. 9777 ref. A. M.

Mesohippus
M. bairdii

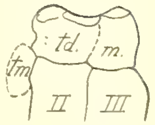
19



No. 1195 ref. A. M.

Miohippus
M. gidleyi

20



No. 14211 Type A. M.

Kalobatippus
K. agatensis

PLATE 40.

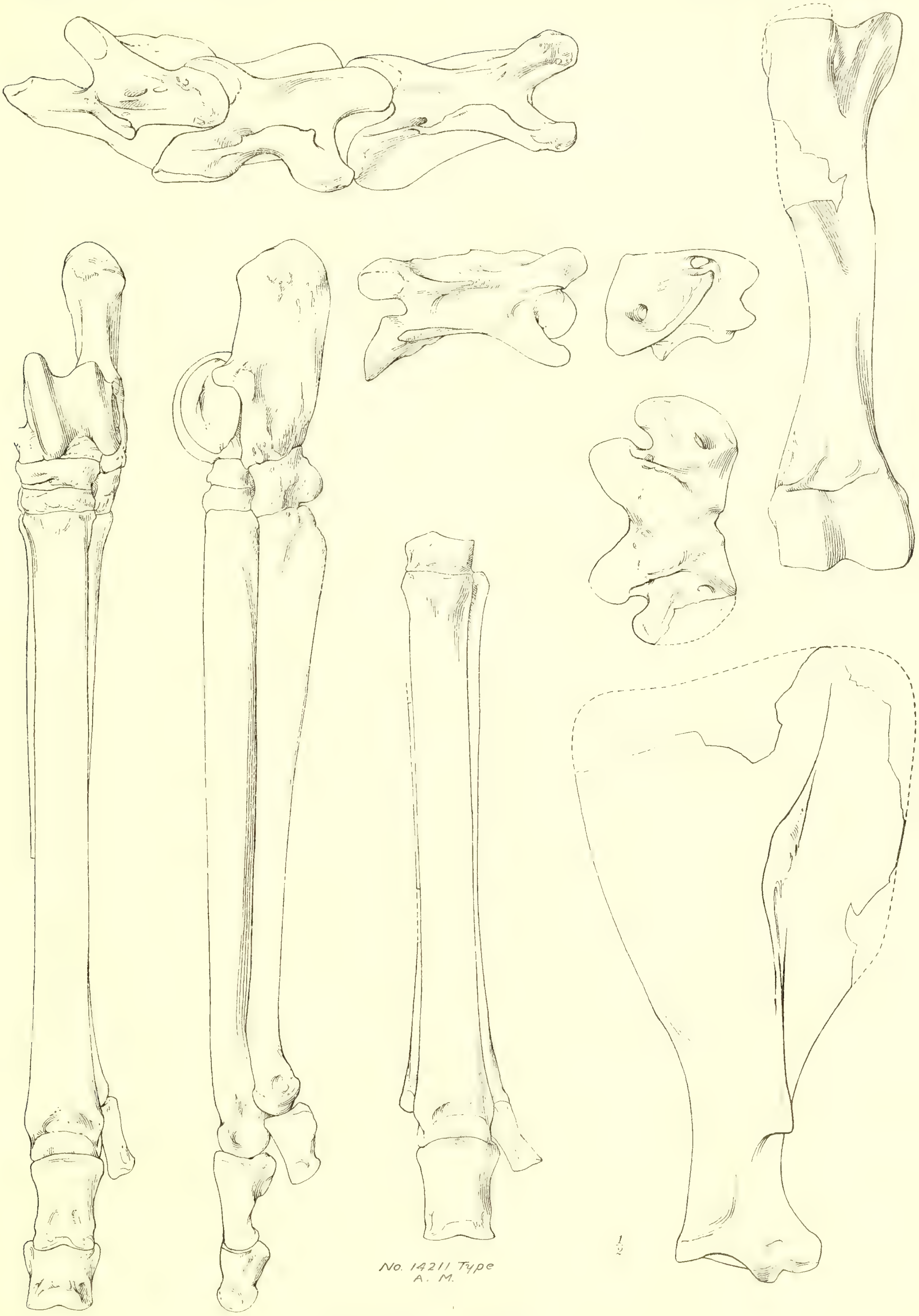
SKELETON, *KALOBATIPPUS.*

PLATE 40.

TYPE SKELETON OF *KALOBATIPPUS AGATENSIS* OSBORN.

One-half natural size.

Lower Harrison, Agate, Nebr.	Lower Miocene	*Kalobatippus agatensis* Osborn, type, Am. Mus. 14211, atlas, cervicals, scapula, humerus, portion of manus, portion of pes, associated with the lower jaw. This animal exceeds the Lower Pliocene *Hipparion* in the length and slenderness of the hind limb, and in the length of the fore limb.



Kalobatippus agatensis

PLATE 41.

FORE FEET, *MERYCHIPPUS.*

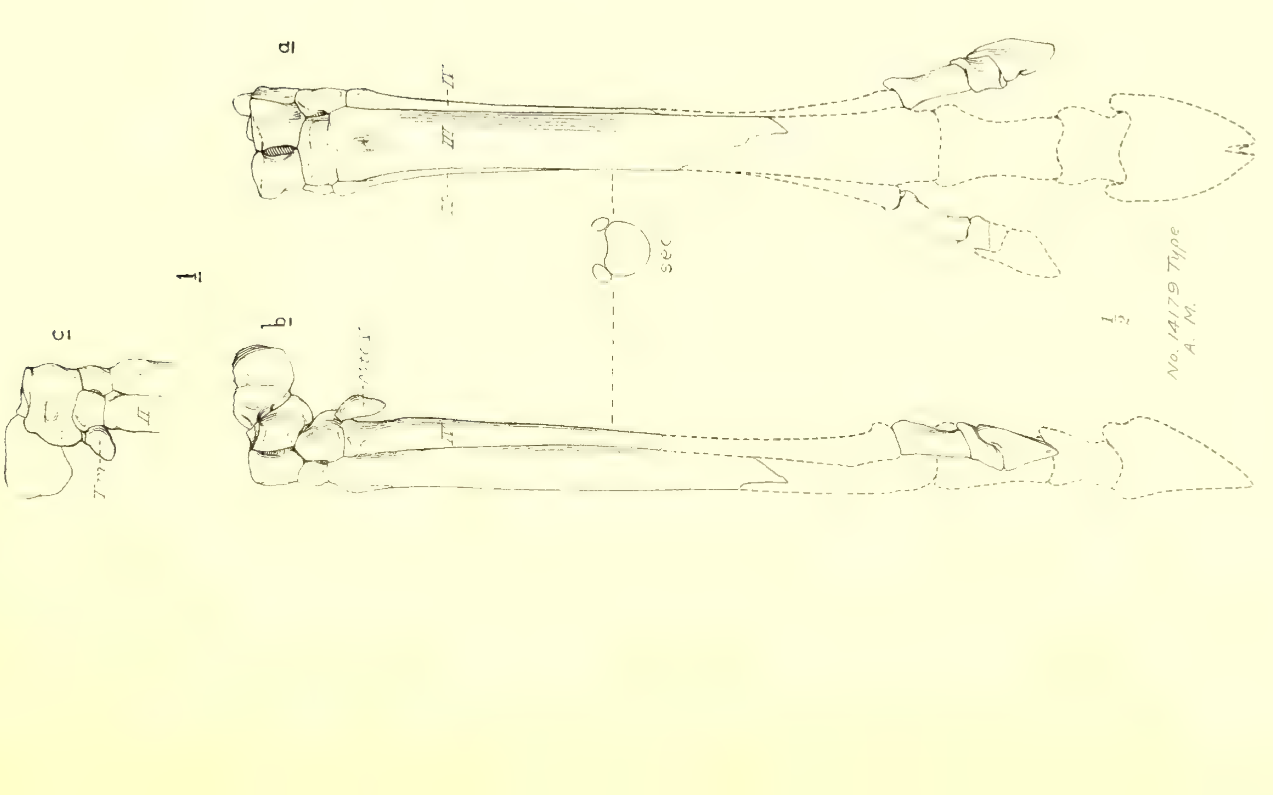
PLATE 41.

FORE FEET OF *MERYCHIPPUS.*

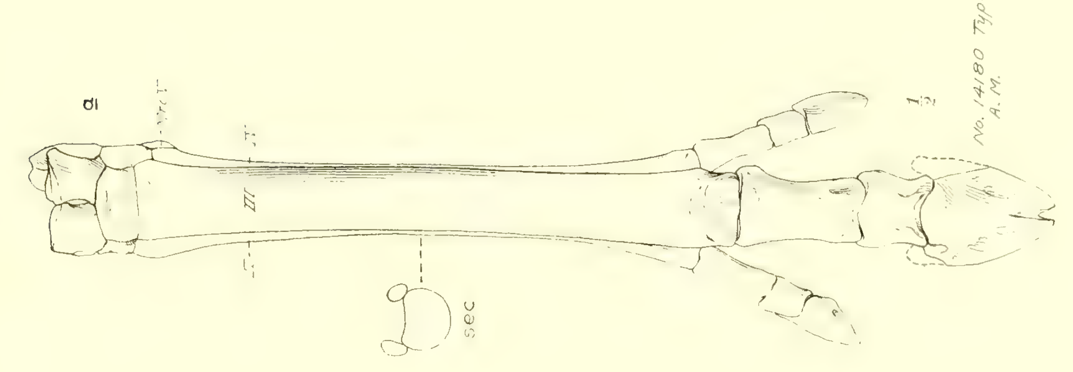
COMPARISON OF THE MANUS IN FOUR SPECIES FROM THE SHEEP CREEK BEDS, NEBRASKA.

All figures one-half natural size.

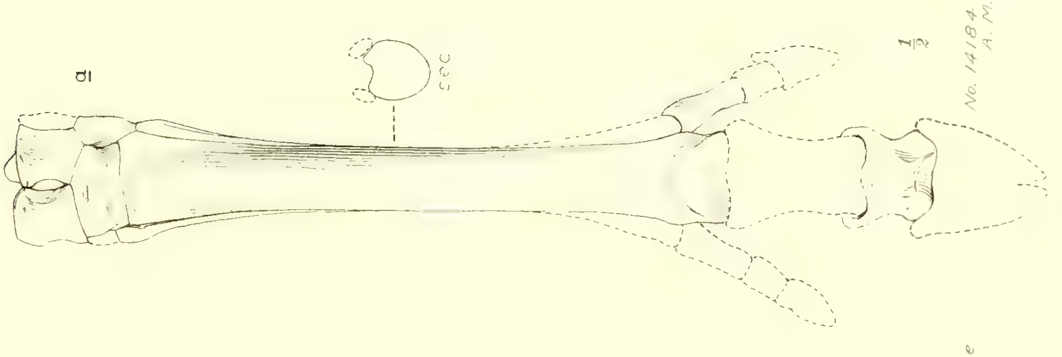
Sheep Creek, Nebr.	Middle Miocene	1. *Merychippus isonesus secundus* Osborn, type, Am. Mus. 14179. *a*, Anterior, *b*, external, *c*, internal view of incomplete fore foot. The nodular vestige of the fifth metacarpal and the trapezium are perfectly preserved in this specimen. The trapezium in flexure of the wrist shifts to a small facet on the second metacarpal, erroneously supposed by previous writers to indicate a vestigial pollex.
" " "	" "	2. *Merychippus isonesus tertius* Osborn, type, Am. Mus. 14180. Anterior view of manus.
" " "	" "	3. *Merychippus isonesus quartus* Osborn, type, Am. Mus. 14184 (reversed in drawing). Anterior view manus.
" " "	" "	4. *Merychippus isonesus quintus* Osborn, type, Am. Mus. 14185. *a*, Anterior and, *b*, external views of manus.



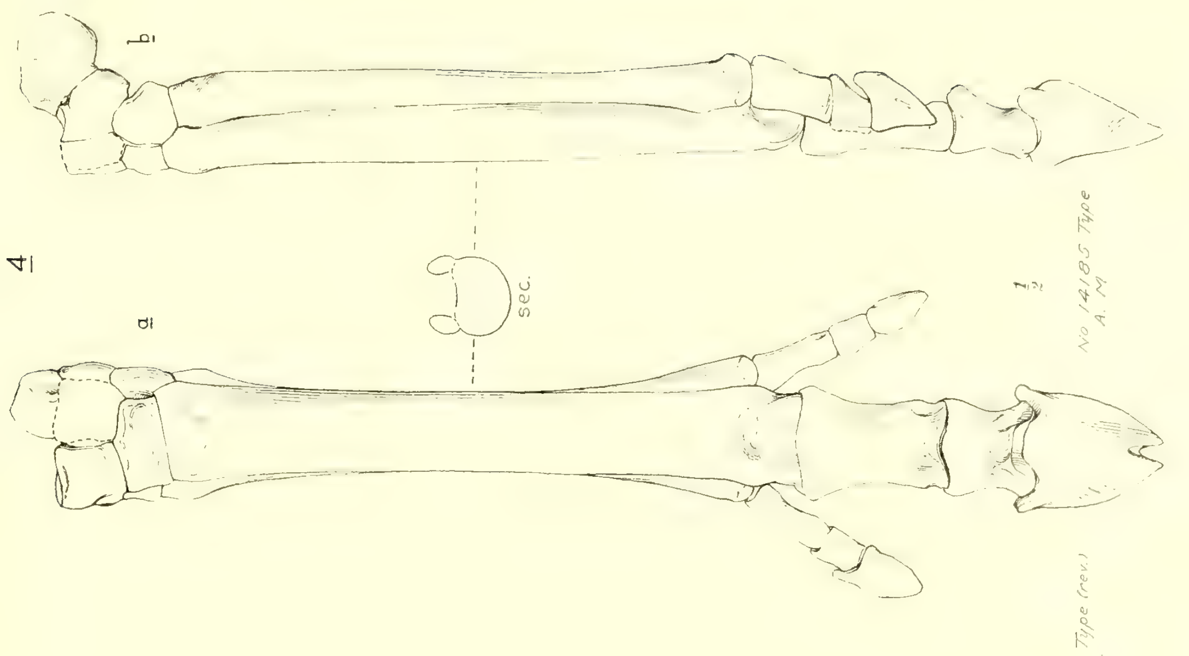
Merychippus isonesus secundus



M. isonesus tertius



M. isonesus quartus



M. isonesus quintus

PLATE 42.

FEET, *MERYCHIPPUS.*

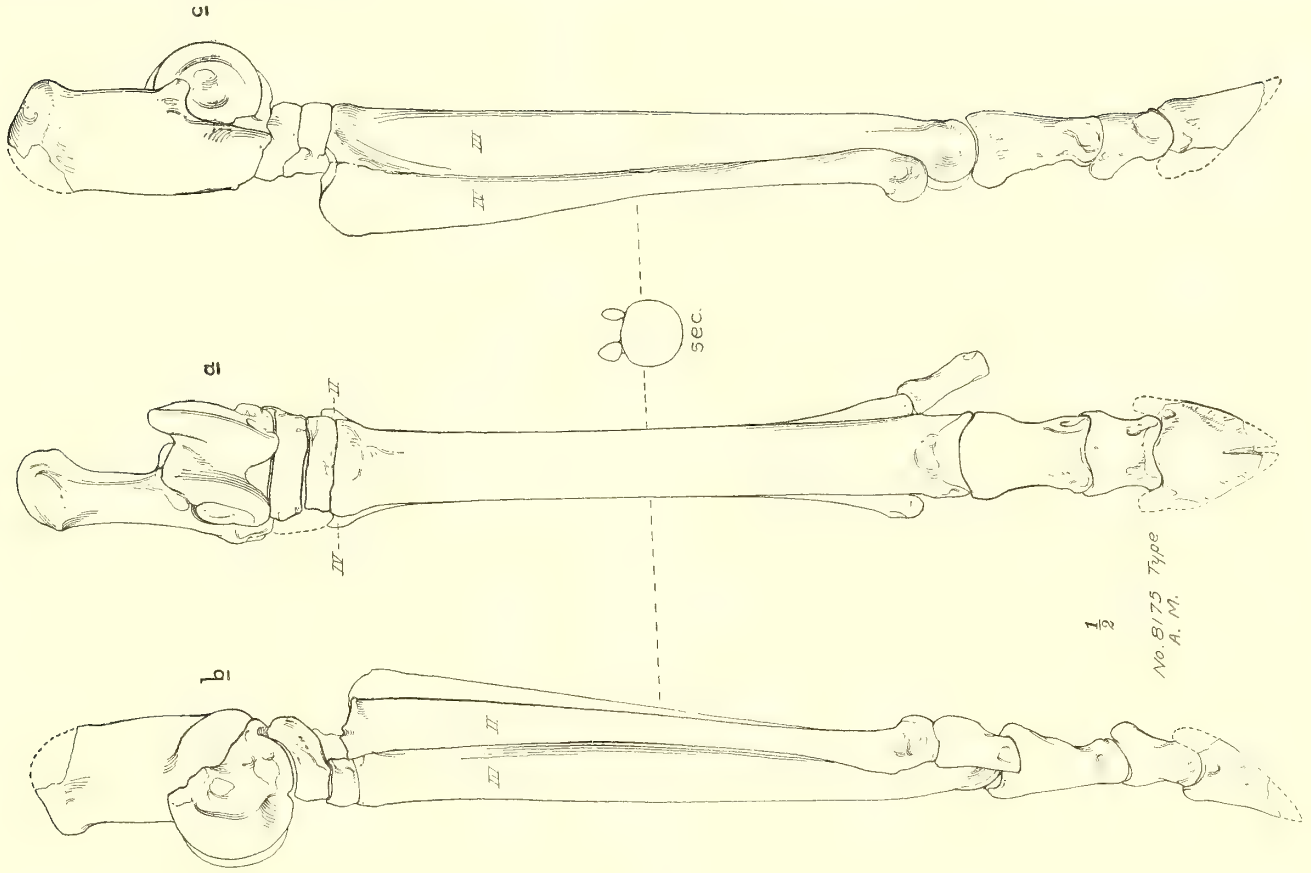
PLATE 42.

FORE AND HIND FOOT OF *MERYCHIPPUS ISONESUS* COPE.

All figures one-half natural size.

Mascall, John Day Basin, Ore.	Middle Miocene	1. *Mesohippus isonesus* Cope, topotype, Am. Mus. 8174a. Associated with limb and foot bones. Metacarpus and proximal phalanx. *a*, Anterior view, *b*, ininternal view.
		2. *Merychippus isonesus* Cope, type, Am. Mus. 8175. Associated with skull, pelvis, and hind limbs. Hind foot, *a*, anterior, *b*, internal, *c*, external view.

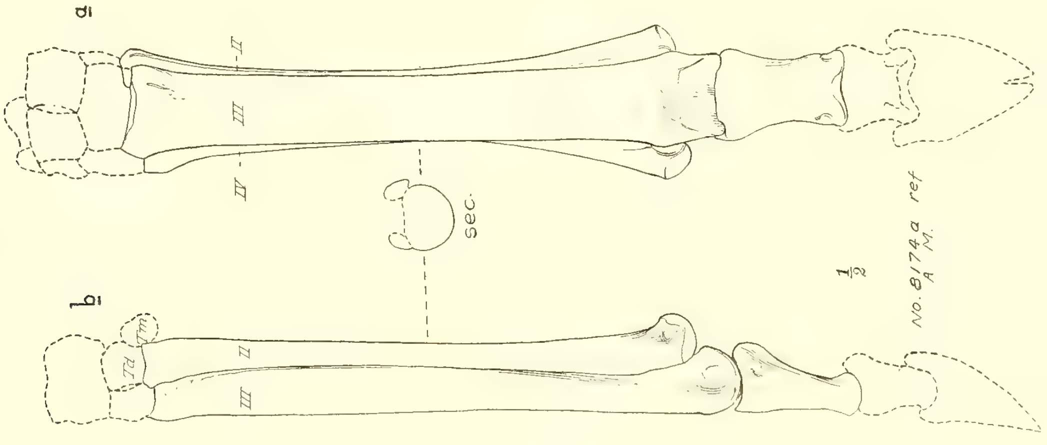
2



1/2 No. 8175 Type A. M.

Merychippus isonesus

1



1/2 No. 8174a ref A. M.

Merychippus isonesus

PLATE 43.

FORE FEET, *MERYCHIPPUS*.

PLATE 43.

FORE FEET OF *MERYCHIPPUS SPHENODUS, M. PANIENSIS, M. SEJUNCTUS.*

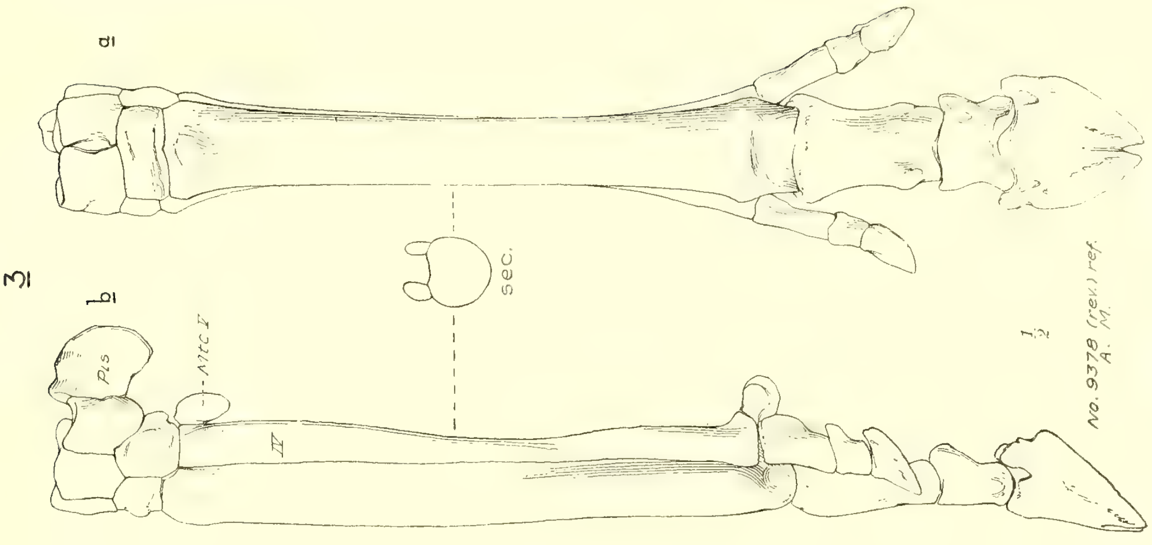
THREE SPECIES FROM THE PAWNEE CREEK BEDS, NORTHEASTERN COLORADO.

All figures one-half natural size.

Front and outer views. The vestigial fifth digit, Mtc. V, is preserved in *M. sejunctus* Cope, Am. Mus. 9378; in the others it is indicated by facets on Mtc. IV but its form is unknown.

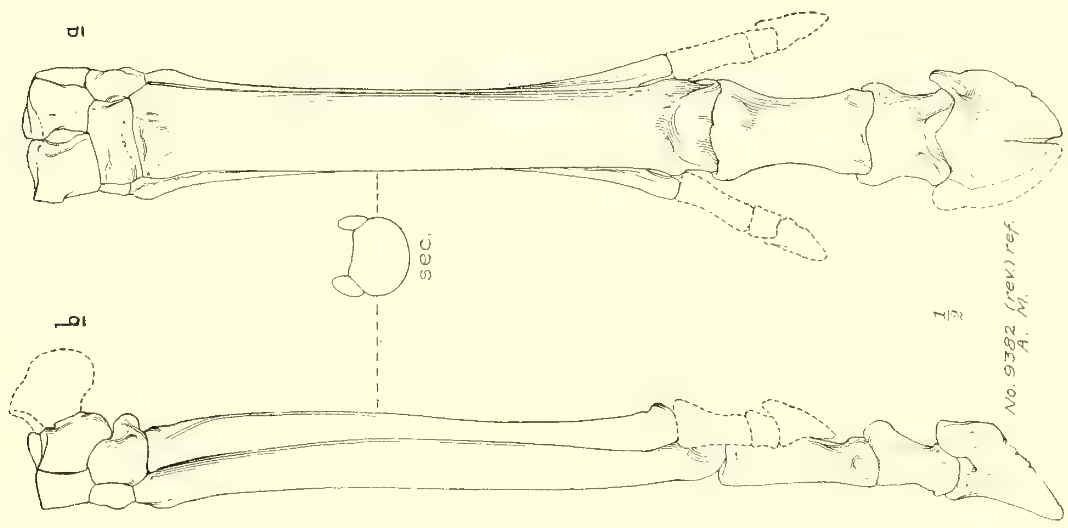
Pawnee Creek, Col.	Middle Miocene	1. *Merychippus sphenodus* Cope, referred specimen, Am. Mus. 9390. Associated with skull. *a*, Anterior and, *b*, external view.
" " "	" "	2. *Merychippus paniensis* Cope, referred specimen, Am. Mus. 9382 (reversed in drawing). Associated with skull, jaws and large part of skeleton. Same views as 1.
" " "	" "	3. *Merychippus sejunctus* Cope, referred specimen, Am. Mus. 9378 (reversed in drawing). Associated with jaws and large part of the skeleton. Same views as 1.

3



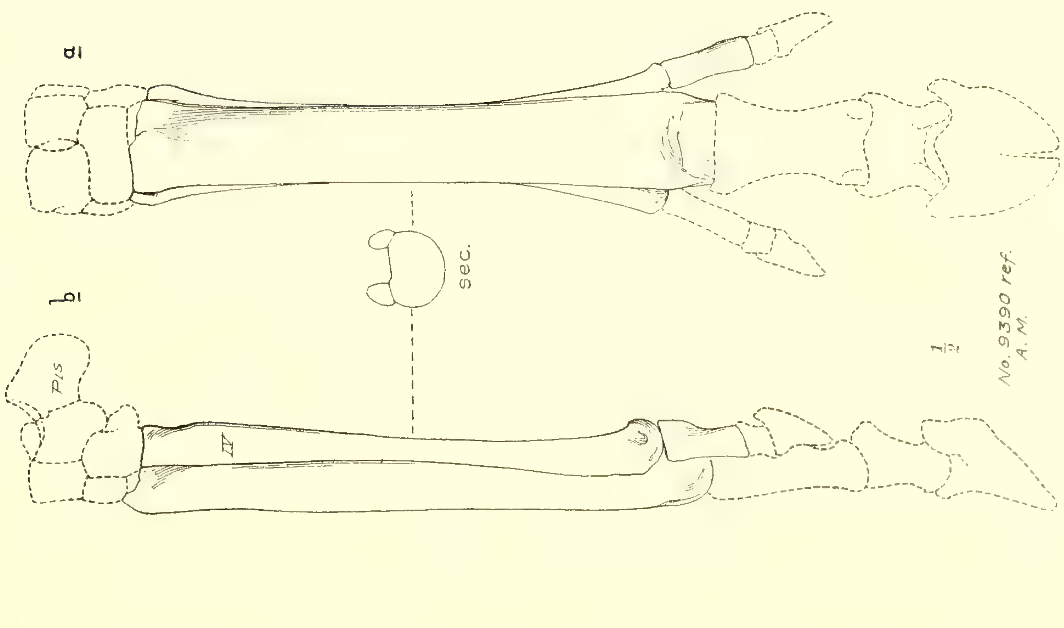
Merychippus sejunctus

2



Merychippus paniensis

1



Merychippus sphenodus

PLATE 44.

FORE FEET, *MERYCHIPPUS.*

PLATE 44.

FORE FEET OF *MERYCHIPPUS CAMPESTRIS, M. EOPLACIDUS, M. EOHIPPARION.*

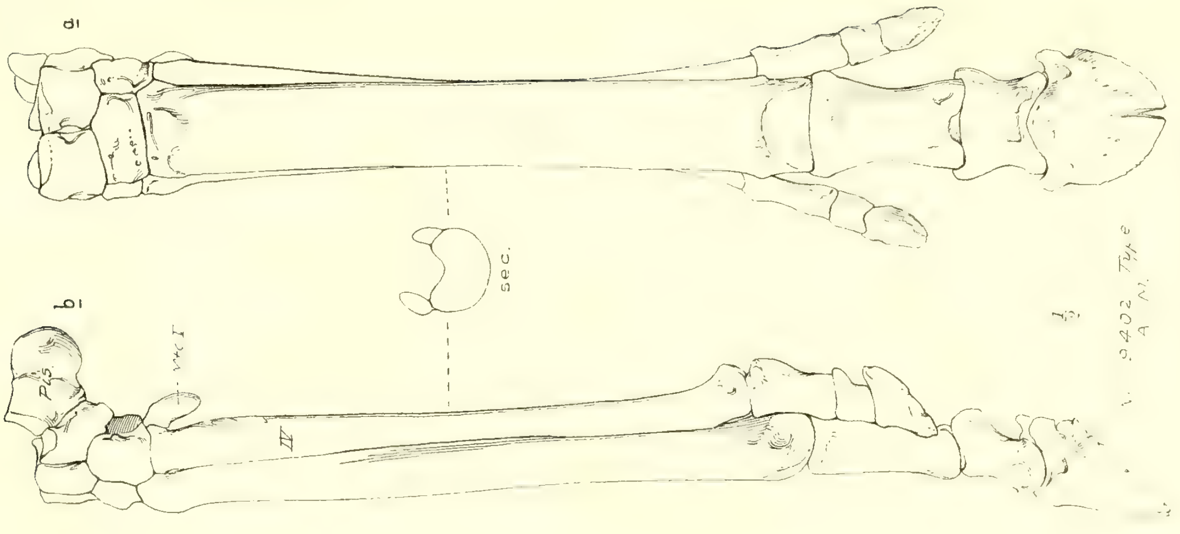
THREE SPECIES FROM THE PAWNEE CREEK BEDS, NORTHEASTERN COLORADO.

All figures one-half natural size.

External and anterior views of manus. The nodular vestige of the fifth digit, Mtc. V, is preserved in two of these specimens.

Pawnee Creek, Col.	Middle Miocene	1. *Merychippus campestris* Gidley, type, Am. Mus. 9096. Associated with upper and lower jaws and large part of skeleton. *a*, Anterior and, *b*, external views.
" " "	" "	2. *M. eoplacidus* Osborn, type, Am. Mus. 9397. Associated with lower jaws and part of skeleton. Same views as 1.
" " "	" "	3. *M. eohipparion* Osborn, type, Am. Mus. 9402. Associated with lower jaws and greater part of skeleton. Same views as 1.

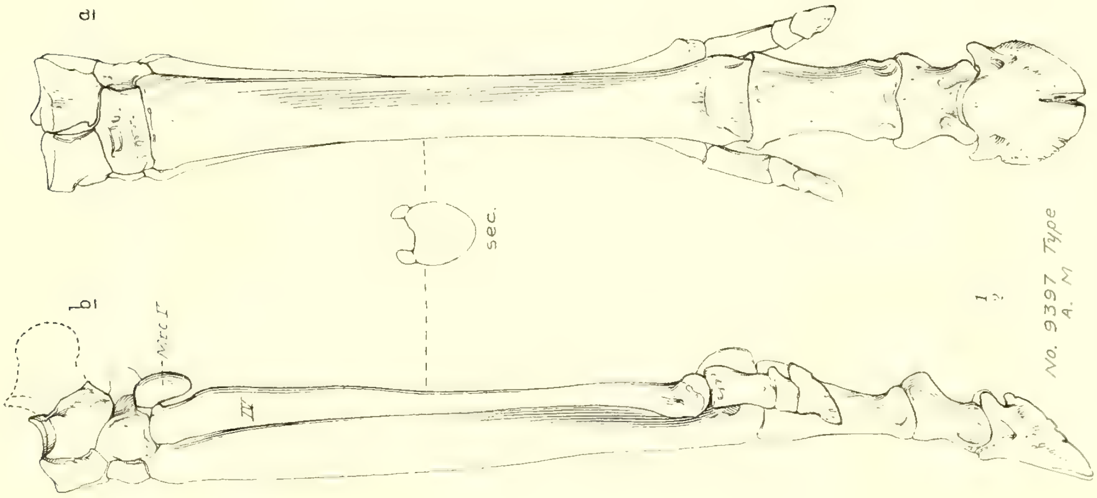
3



1/2 No. 9402 Type A. M.

Merychippus eohipparion.

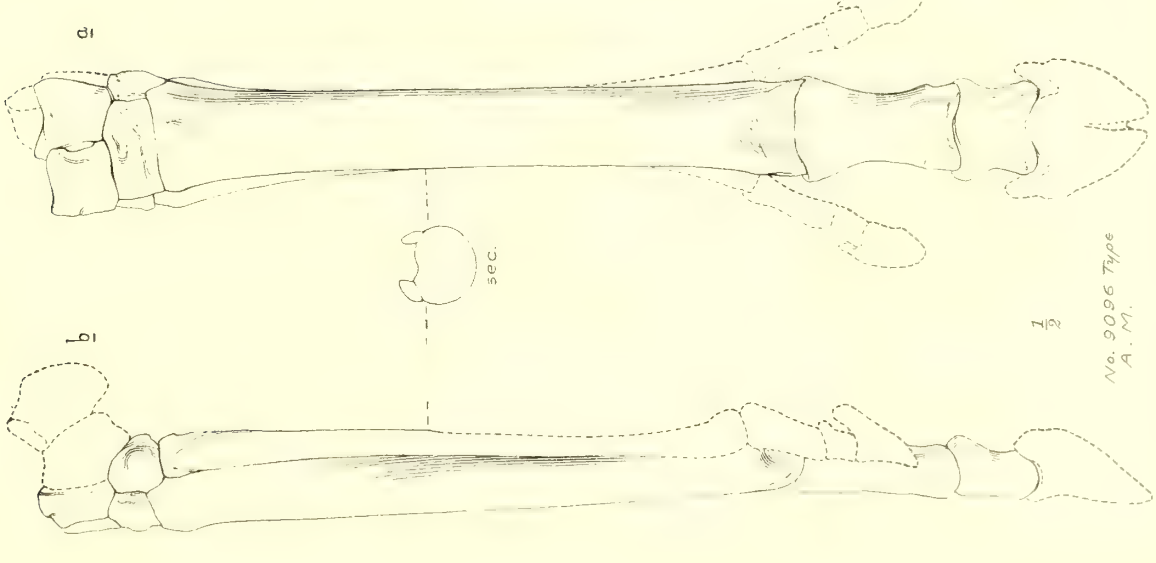
2



1/2 No. 9397 Type A. M.

Merychippus eoplacidus

1



1/2 No. 9096 Type A. M.

Merychippus campestris

PLATE 45.

HUMERUS, TIBIA, *MERYCHIPPUS.*

PLATE 45.

HUMERUS AND TIBIA OF *MERYCHIPPUS ISONESUS SECUNDUS, M. ISONESUS QUARTUS, M. ISONESUS QUINTUS.*

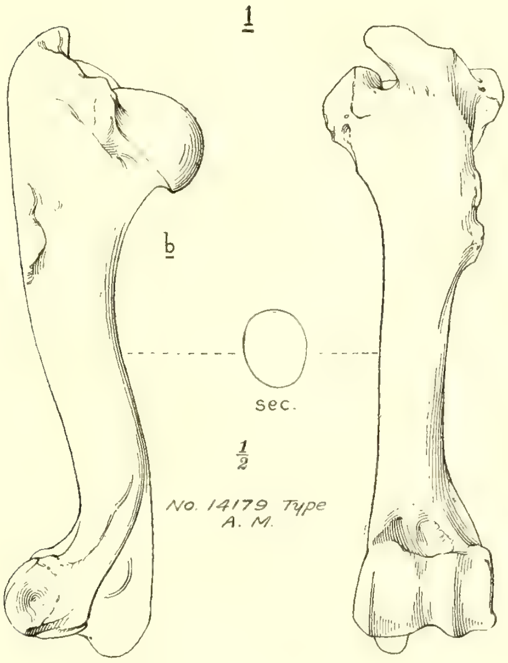
COMPARISON OF THREE SPECIES FROM THE SHEEP CREEK BEDS, SIOUX COUNTY, NEBR.

All figures one-half natural size.

Note the differences in proportion between *M. isonesus secundus* and *M. isonesus quintus; M. isonesus quartus* is intermediate.

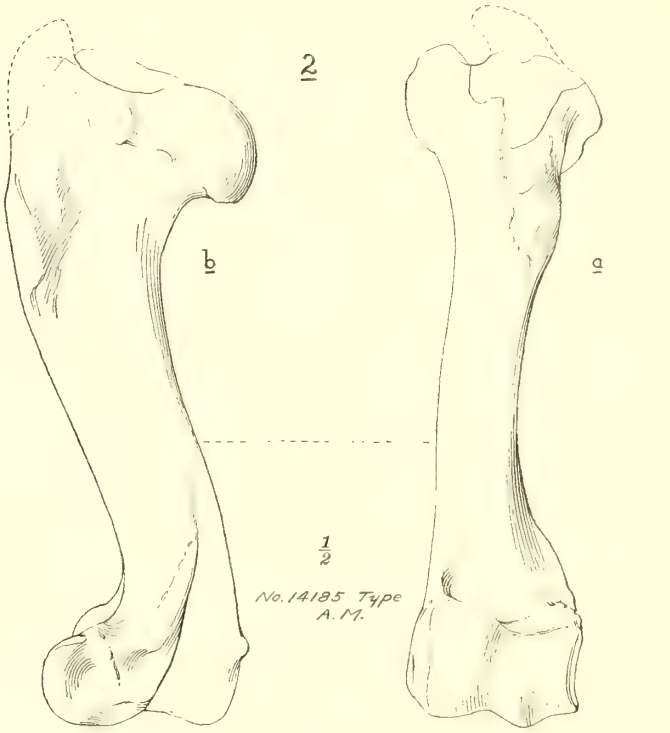
Sheep Creek, Nebr.	Middle Miocene	1, 3.	*Merychippus isonesus secundus* Osborn, type, Amer. Mus. 14179. 1, Humerus, 3, tibia, *a*, anterior, *b*, external view.
“ “ “	“ “	4.	*M. isonesus quartus* Osborn, type, Am. Mus. 14184. Anterior view of tibia. (Reversed in drawing).
“ “ “	“ “	2, 5.	*M. isonesus quintus* Osborn, type, Am. Mus. 14185. 2, Humerus, 5, tibia, *a*, anterior, *b*, external view.

1



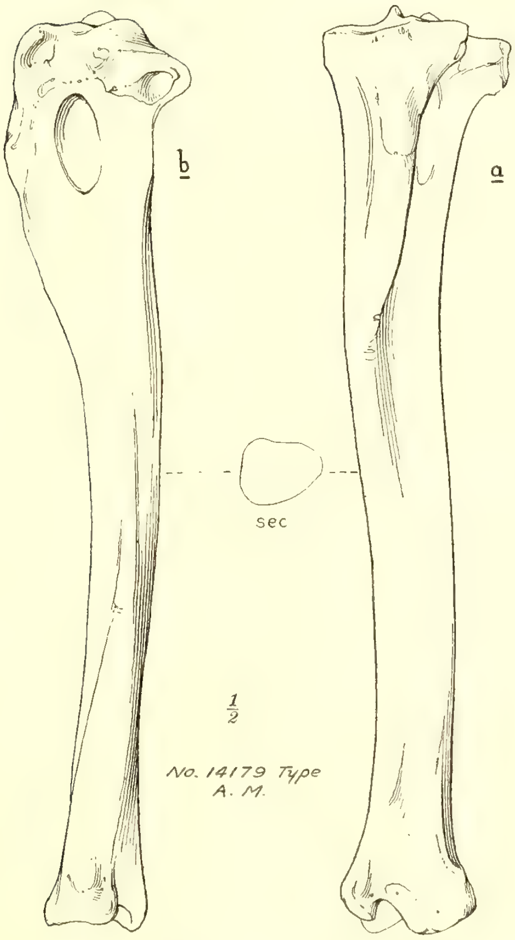
Merychippus isonesus secundus

2



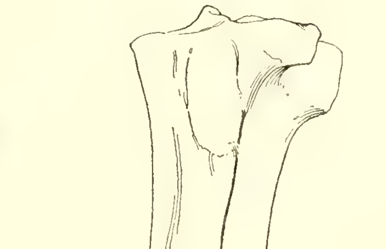
M. isonesus quintus

3



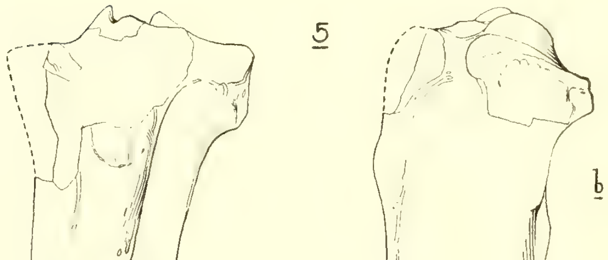
M. isonesus secundus

4



M. isonesus quartus

5



M. isonesus quintus

L. M. S.

PLATE 46.

ULNA, RADIUS, *MERYCHIPPUS.*

PLATE 46.

ULNO-RADIUS OF *MERYCHIPPUS ISONESUS SECUNDUS, M. ISONESUS TERTIUS, M. ISONESUS QUARTUS, M. ISONESUS QUINTUS.*

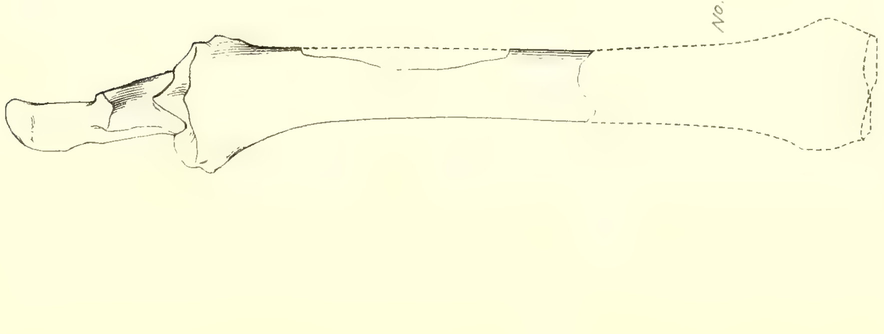
ANTERIOR AND EXTERNAL VIEWS IN FOUR SPECIES FROM THE SHEEP CREEK BEDS OF NEBRASKA.

The ulnar and radial shafts in *Merychippus* are partly coössified, the extent of coössification varying in different species and with age.

All figures one-half natural size.

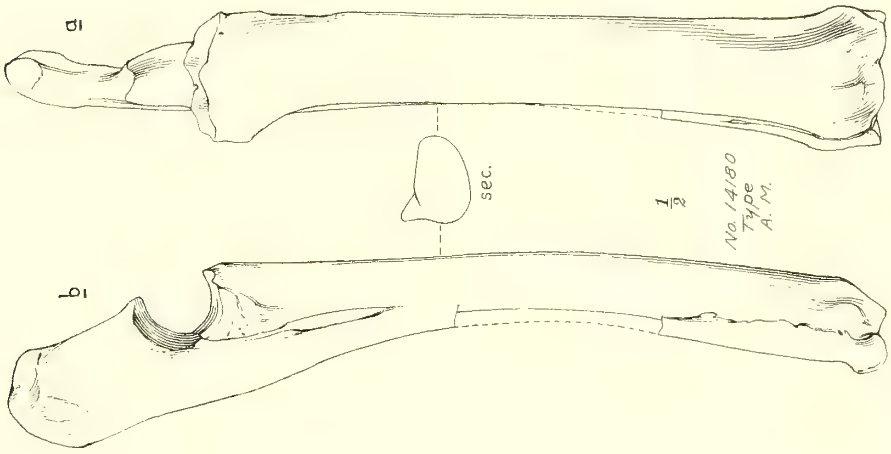
Sheep Creek, Nebr.	Middle Miocene	1. *Merychippus isonesus secundus* Osborn, type, Am. Mus. 14179. Anterior view.
" " "	" "	2. *M. isonesus tertius* Osborn, type, Am. Mus. 14180. *a*, Anterior, *b*, external view.
" " "	" "	3. *M. isonesus quartus* Osborn, type, Am. Mus. 14184. Anterior view.
" " "	" "	4. *M. isonesus quintus* Osborn, type, Am. Mus. 14185. *a*, Anterior, *b*, external view.

1



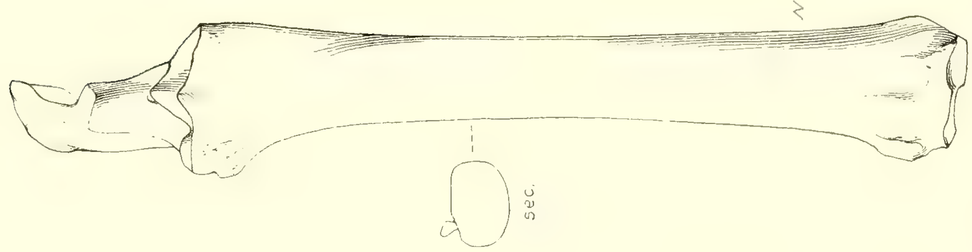
Merychippus isonesus secundus

2



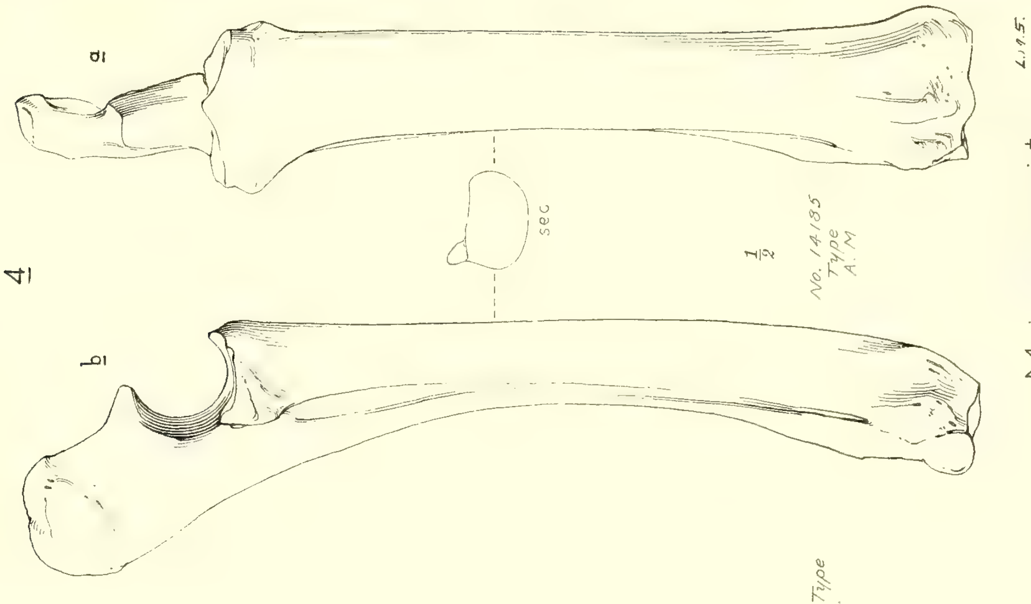
M. isonesus tertius

3



M. isonesus quartus

4



M. isonesus quintus

PLATE 47.

HUMERUS, *MERYCHIPPUS.*

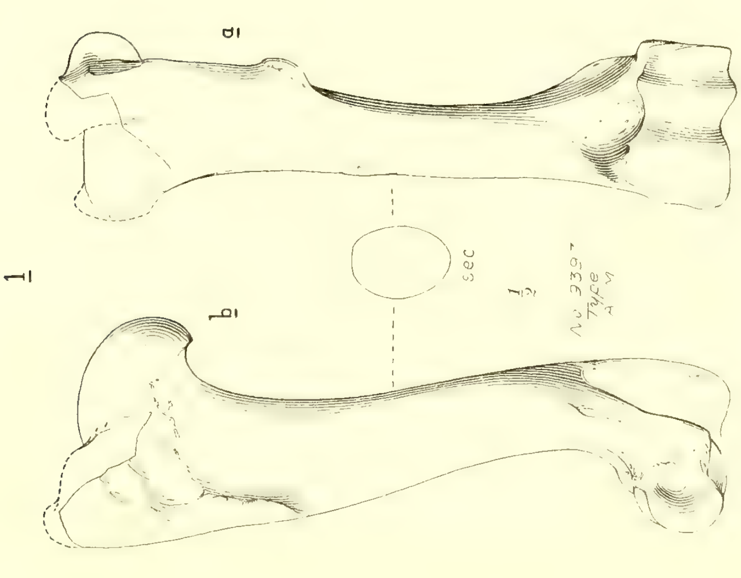
PLATE 47.

HUMERUS OF *MERYCHIPPUS EOPLACIDUS, M. SPHENODUS, M. EOHIPPARION.*

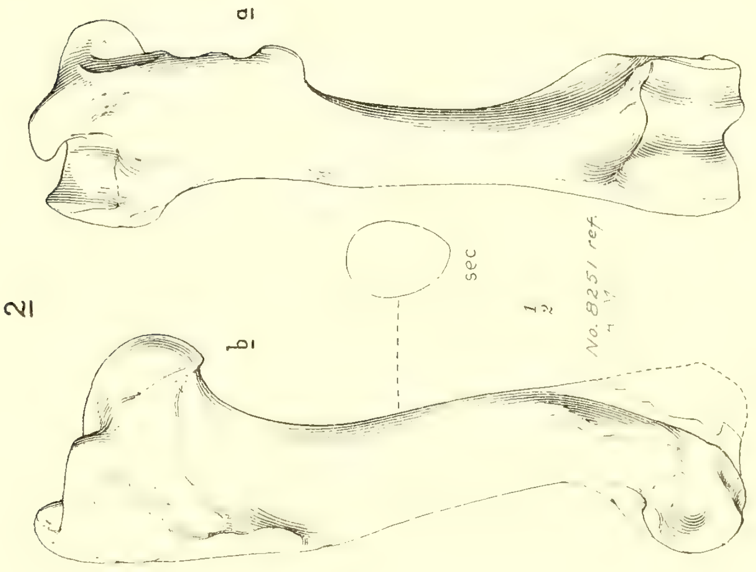
COMPARISON OF THREE SPECIES FROM THE PAWNEE CREEK BEDS OF NORTHEASTERN COLORADO.

All figures one-half natural size.

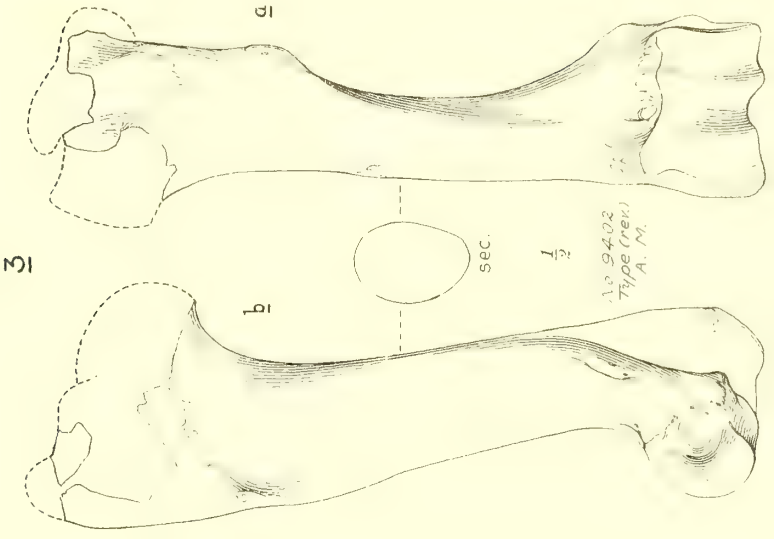
Pawnee Creek, Col.	Middle Miocene	1. *Merychippus eoplacidus* Osborn, type, Am. Mus. 9397. Associated with lower jaws and part of skeleton. *a*, Anterior, *b*, external views.
“ “ “	“ “	2. *M. sphenodus* Cope, referred specimen, Am. Mus. 8251. Associated with teeth and part of skeleton. Same views as 1.
“ “ “	“ “	3. *M. eohipparion* Osborn, type, Am. Mus. 9402 (reversed in drawing). Associated with lower jaws and greater part of skeleton. Same views as 1.



Merychippus eoplacidus



Merychippus sphenodus



Merychippus eohipparion

PLATE 48.

ULNA, RADIUS, *MERYCHIPPUS*.

PLATE 48.

ULNO-RADIUS OF *MERYCHIPPUS SEJUNCTUS, M. PANIENSIS, M. SPHENODUS.*

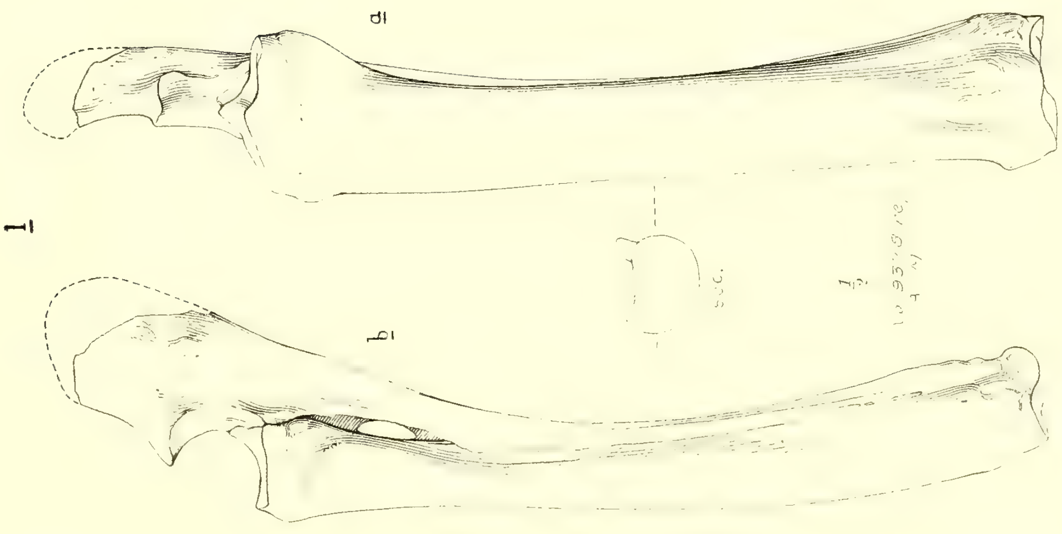
COMPARISON OF FOREARM BONES IN THREE SPECIES FROM THE PAWNEE CREEK BEDS OF NORTHEASTERN COLORADO.

All figures one-half natural size.

Anterior and external views. Shaft of ulna coössified more than in species of the Sheep Creek and Mascall beds, but with distinct traces of separation in distal portion.

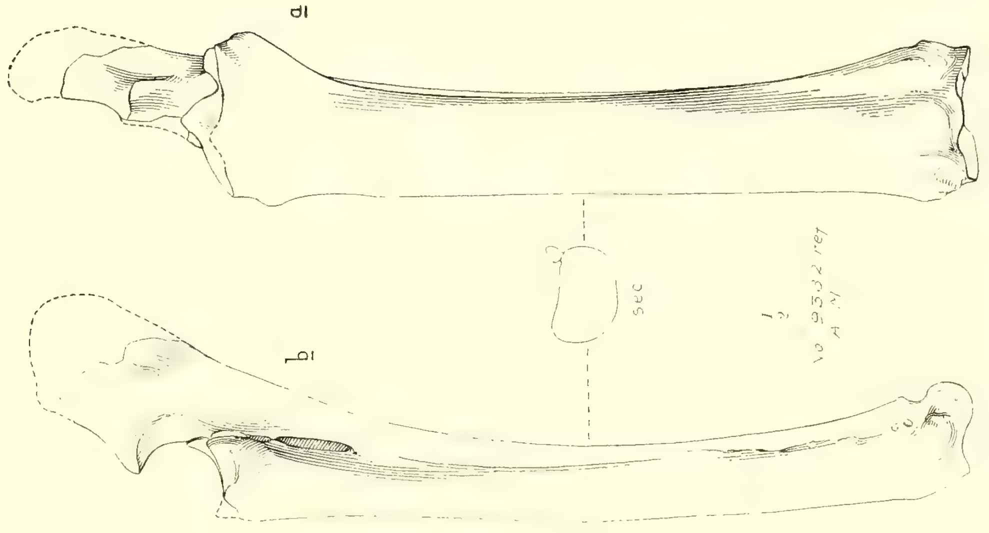
Pawnee Creek, Col.	Middle Miocene	1. *Merychippus sejunctus* Cope, referred specimen, Am. Mus. 9378. Associated with lower jaws and large part of skeleton. *a*, Anterior and, *b*, external views.
" " "	" "	2. *M. paniensis* Cope, referred specimen, Am. Mus. 9382. Associated with skull, jaws, and large part of skeleton. Same views as 1.
" " "	" "	3. *M. sphenodus* Cope, referred specimen, Am. Mus. 8251. Associated with part of skeleton. Same views as 1.

1



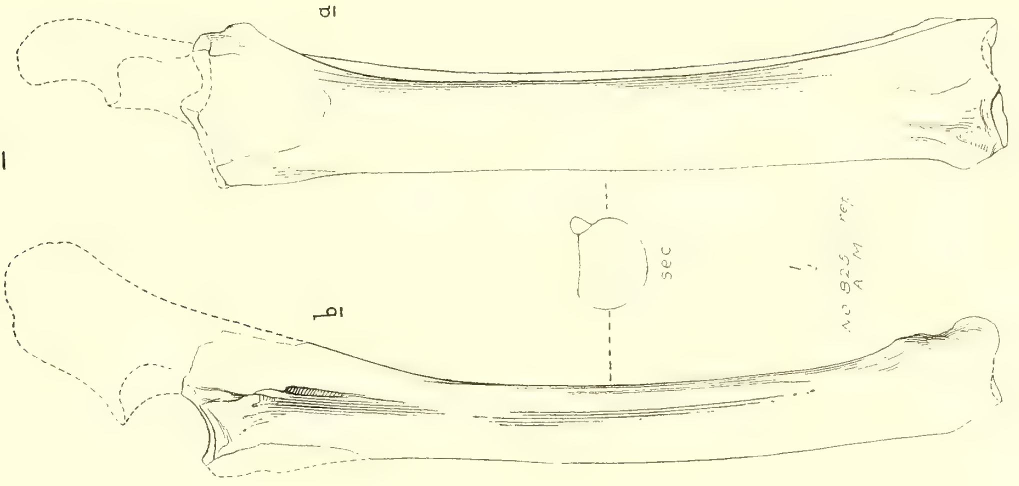
Merychippus sejunctus

2



Merychippus paniensis

3



Merychippus sphenodus

PLATE 49.

ULNA, RADIUS, *MERYCHIPPUS.*

PLATE 49.

ULNO-RADIUS OF *MERYCHIPPUS CAMPESTRIS, M. EOPLACIDUS, M. EOHIPPARION.*

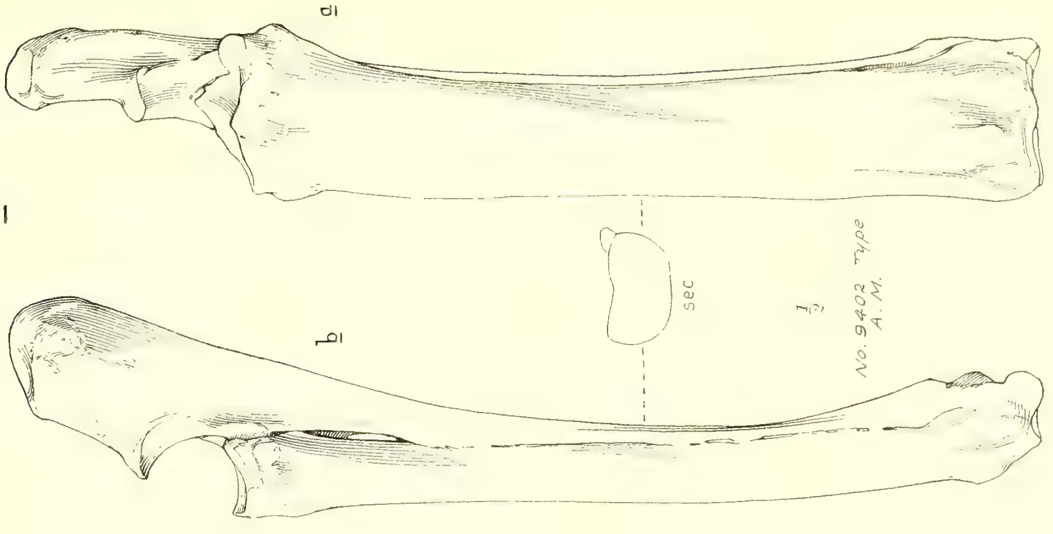
COMPARISON OF THREE SPECIES FROM THE PAWNEE CREEK BEDS OF NORTHEASTERN COLORADO.

All figures one-half natural size.

The ulnar shaft is much reduced in *M. campestris* and *M. eoplacidus*, and imperfectly united to radius in all. Compare Plate 50.

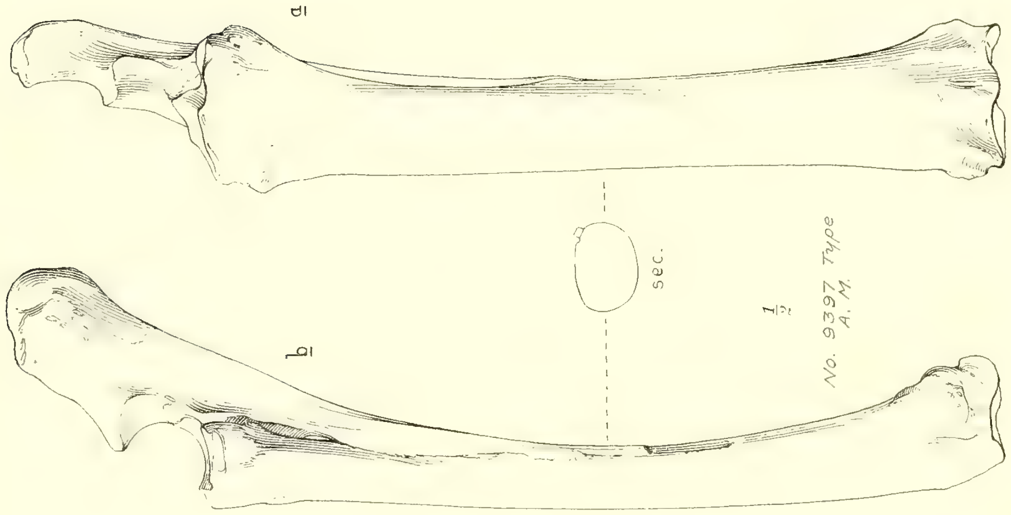
Pawnee Creek, Col.	Middle Miocene	1. *Merychippus campestris* Gidley, type, Am. Mus. 9096. Associated with upper and lower jaws and large part of skeleton. *a*, Anterior, *b*, external views.
" " "	" "	2. *M. eoplacidus* Osborn, type, Am. Mus. 9397. Associated with lower jaws and part of skeleton. Same views as 1.
" " "	" "	3. *M. eohipparion* Osborn, type, Am. Mus. 9402. Associated with lower jaws and greater part of skeleton. Same views as 1.

3



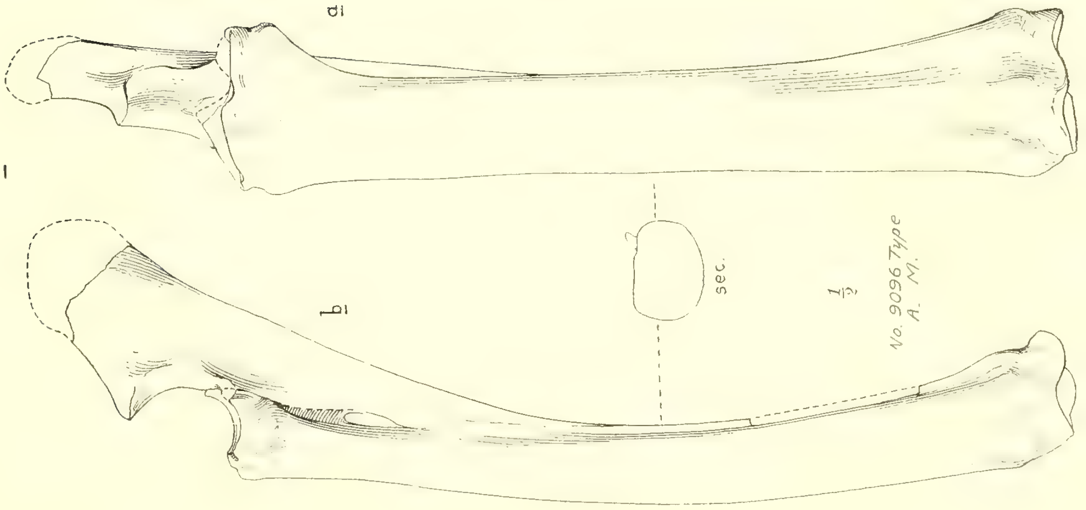
Merychippus eohipparion

2



Merychippus eoplacidus

1



Merychippus campestris

L.M.S.

PLATE 50.

FEMUR, TIBIA, *MERYCHIPPUS.*

PLATE 50.

FEMUR AND TIBIA IN *MERYCHIPPUS SEJUNCTUS, M. PANIENSIS, M. CAMPESTRIS, M. EOHIPPARION.*

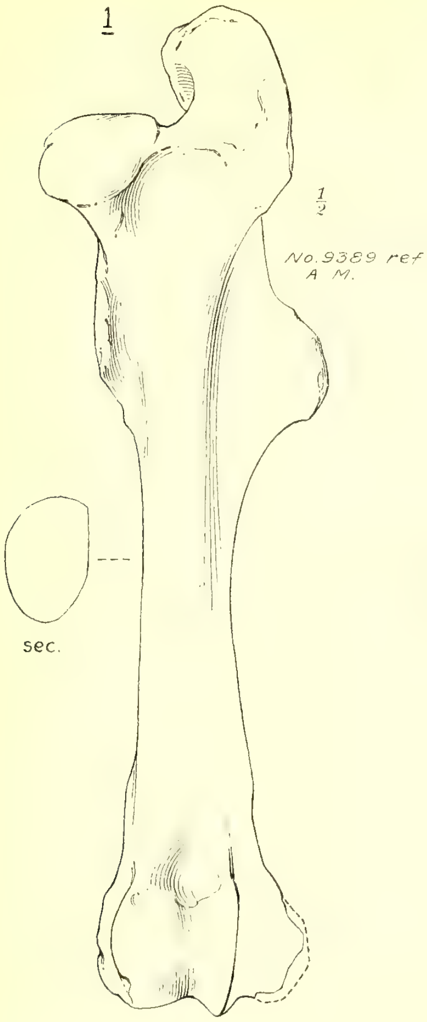
FOUR SPECIES FROM THE PAWNEE CREEK BEDS OF NORTHEASTERN COLORADO.

All figures one-half natural size.

(Upper) Femora, (lower) tibiæ, anterior views.

Pawnee Creek, Col.	Middle Miocene	1, 5.	*Merychippus sejunctus* Cope, referred specimen, Am. Mus. 9389. Associated with hind limb and foot.
" " "	" "	2, 6.	*M. paniensis* Cope, referred specimen, Am. Mus. 9382. (Femur reversed in drawing). Associated with skull, jaws and greater part of skeleton.
" " "	" "	3, 7.	*M. campestris* Gidley, type, Am. Mus. 9096 (reversed in drawing). Associated with upper and lower jaws and greater part of the skeleton.
" " "	" "	4, 8.	*M. eohipparion* Osborn, type, Am. Mus. 9402 (tibia reversed in drawing). Associated with lower jaws and greater part of skeleton.

1



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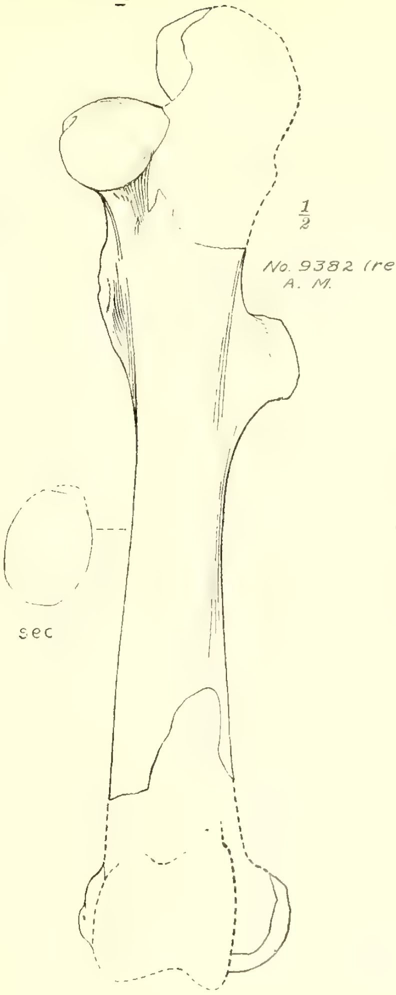

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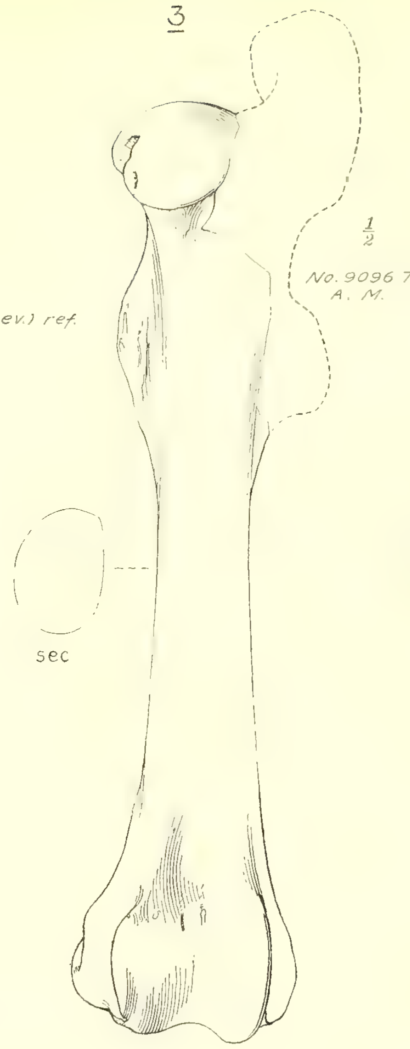

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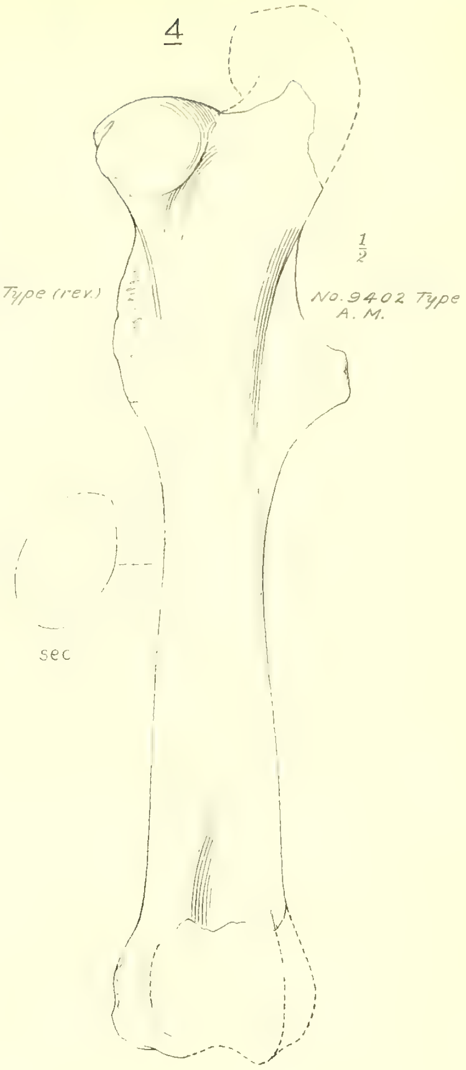

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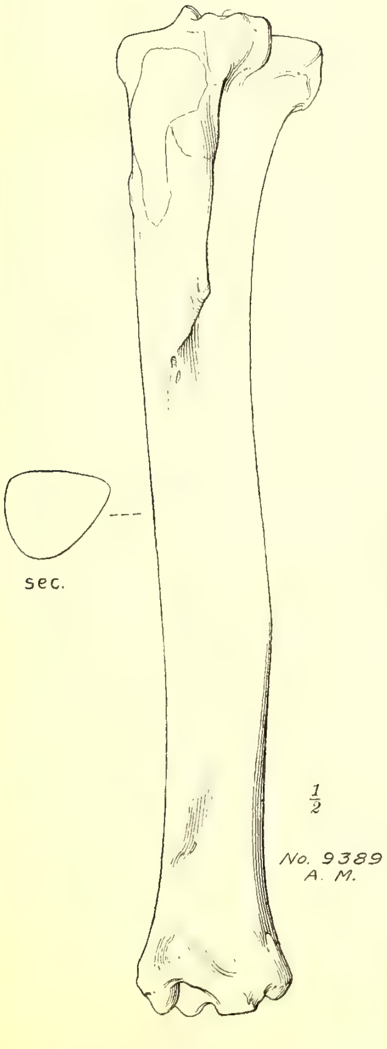

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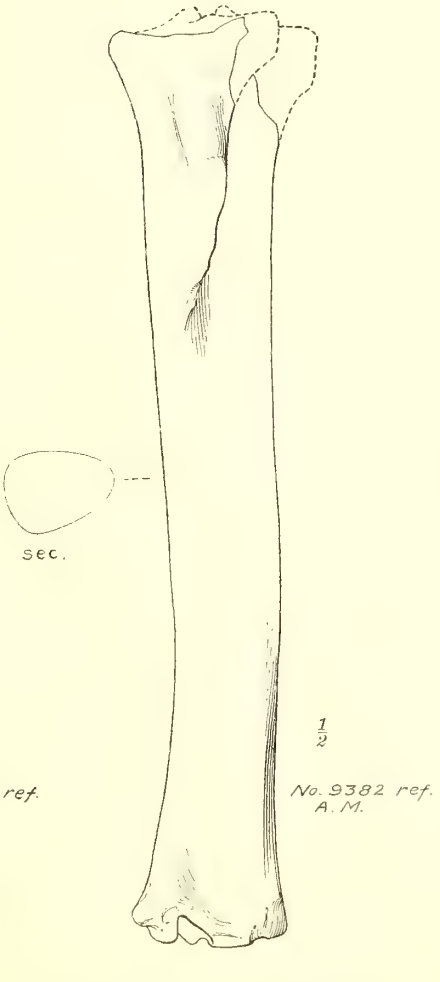

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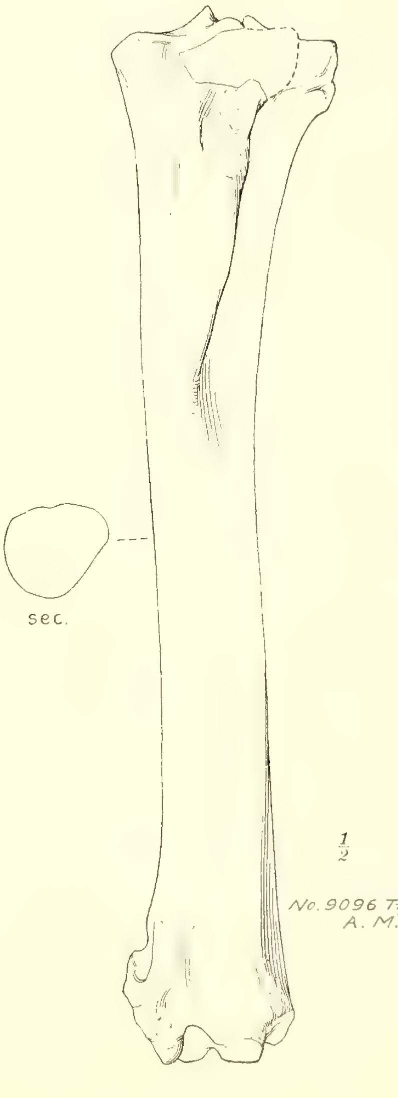

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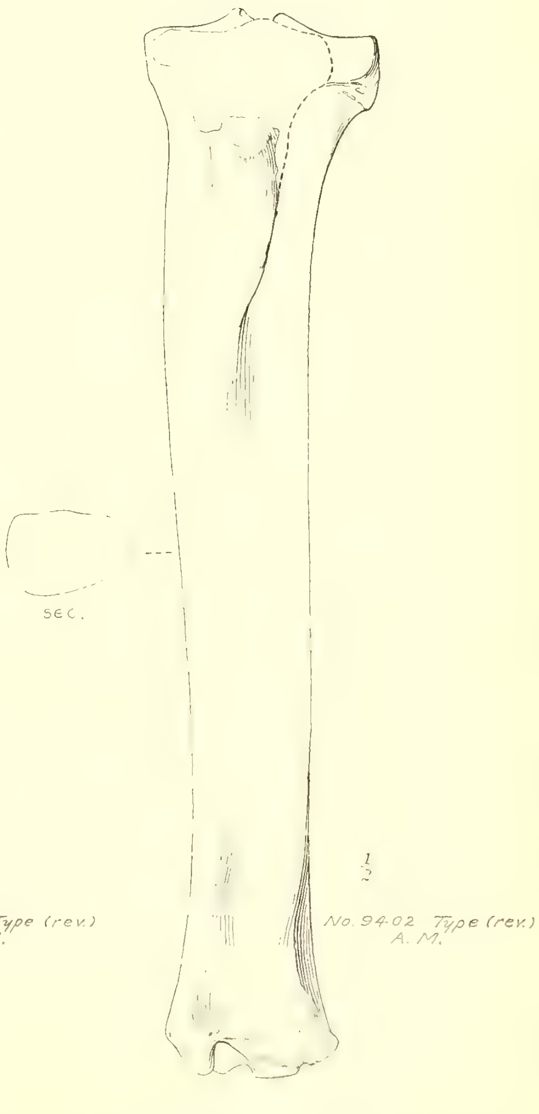


Merychippus sejunctus   Merychippus paniensis   Merychippus campestris   Merychippus eohipparion

L.M.S.

PLATE 51.

TARSUS, ANCHITHERIINÆ, *HYPOHIPPUS.*

PLATE 51.

ADAPTIVE REDUCTION OF TARSUS IN ANCHITHERIINÆ AND IN *HIPPARION*.

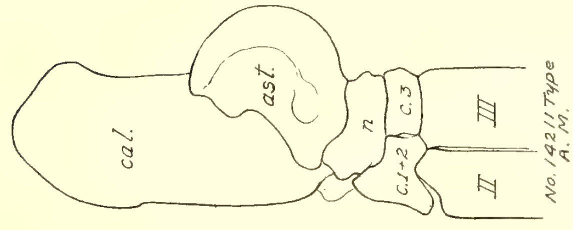
DIAGRAMS SHOWING RELATIONS OF LATERAL TARSALS TO MEDIAN METATARSAL.

All figures natural size.

Figs. 1–3, 7–10 inner side of tarsus; Figs. 4–6, 11–14 outer side of tarsus.

Middle Oligocene	7, 11	*Mesohippus* (*M. bairdii*, referred specimen, Am. Mus. 670). Cannon bone articulates with ectocuneiform only, giving no support either to cuboid or internal cuneiform.
Upper Oligocene	8, 9, 12, 13	*Miohippus* (8, 12 *M. gidleyi*, referred specimen, Am. Mus. 705; 9, 13 *M. equiceps*, referred specimen, Am. Mus. 7262). Cannon bone articulates with ectocuneiform and cuboid but gives no support to inner cuneiform.
Uppermost Oligocene	1, 4, 10, 14	*Kalobatippus* (1, 4 *K. agatensis*, type, Am. Mus. 14211; 10, 14 *K. præstans*, type, Am. Mus. 7269). Cannon bone articulates with ectocuneiform, cuboid, and inner cuneiform, the two latter articulations narrow, oblique.
Middle Miocene	2, 5	*Hypohippus* (*H. osborni*, type, Am. Mus. 9407). Cannon bone articulates with entocuneiform, cuboid, and inner cuneiform, the cuboid articulation somewhat oblique.
Lower Pliocene	3, 6	*Hipparion* (*H. whitneyi*, type, Am. Mus. 9815). Cannon bone articulates with ectocuneiform and cuboid but does not support inner cuneiform.

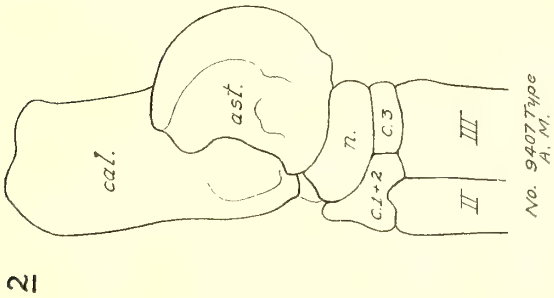
1



No. 14211 Type A. M.

Kalobatippus
K. agatensis

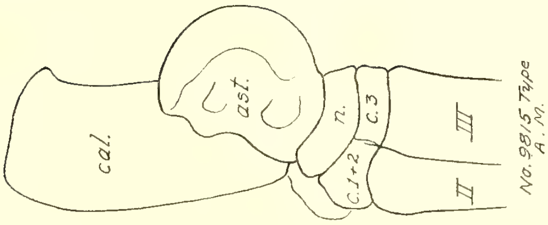
2



No. 9407 Type A. M.

Hypohippus
H. osborni

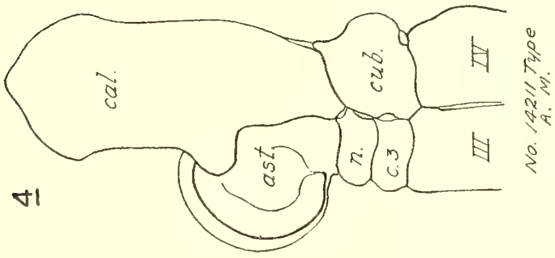
3



No. 9815 Type A. M.

Hipparion
H. whitneyi

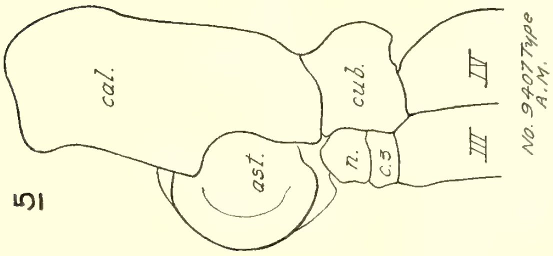
4



No. 14211 Type A. M.

Kalobatippus
K. agatensis

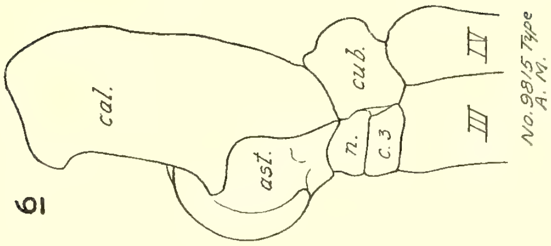
5



No. 9407 Type A. M.

Hypohippus
H. osborni

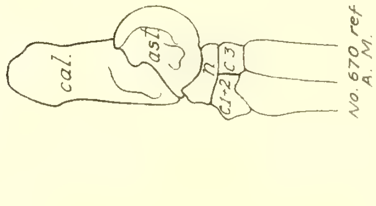
6



No. 9815 Type A. M.

Hipparion
H. whitneyi

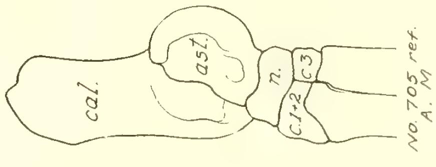
7



No. 670 ref. A. M.

Mesohippus
M. bairdii

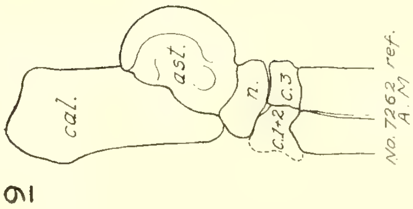
8



No. 705 ref. A. M.

Miohippus
M. gidleyi

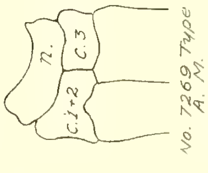
9



No. 7262 ref. A. M.

Miohippus
M. equiceps

10

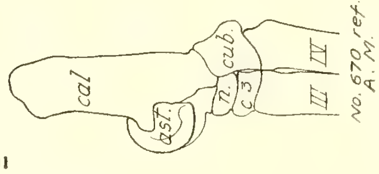


No. 7269 Type A. M.

Kalobatippus
K. praestans

1/2

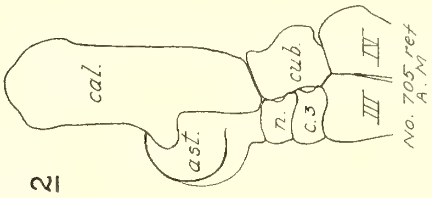
11



No. 670 ref. A. M.

Mesohippus
M. bairdii

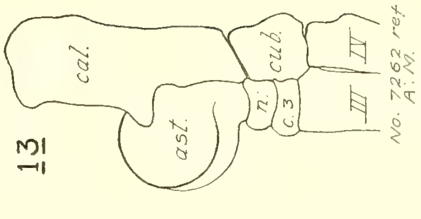
12



No. 705 ref. A. M.

Miohippus
M. gidleyi

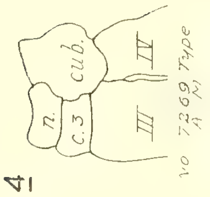
13



No. 7262 ref. A. M.

Miohippus
M. equiceps

14



No. 7269 Type A. M.

Kalobatippus
K. praestans

PLATE 52.

HIND FEET, *MERYCHIPPUS.*

PLATE 52.

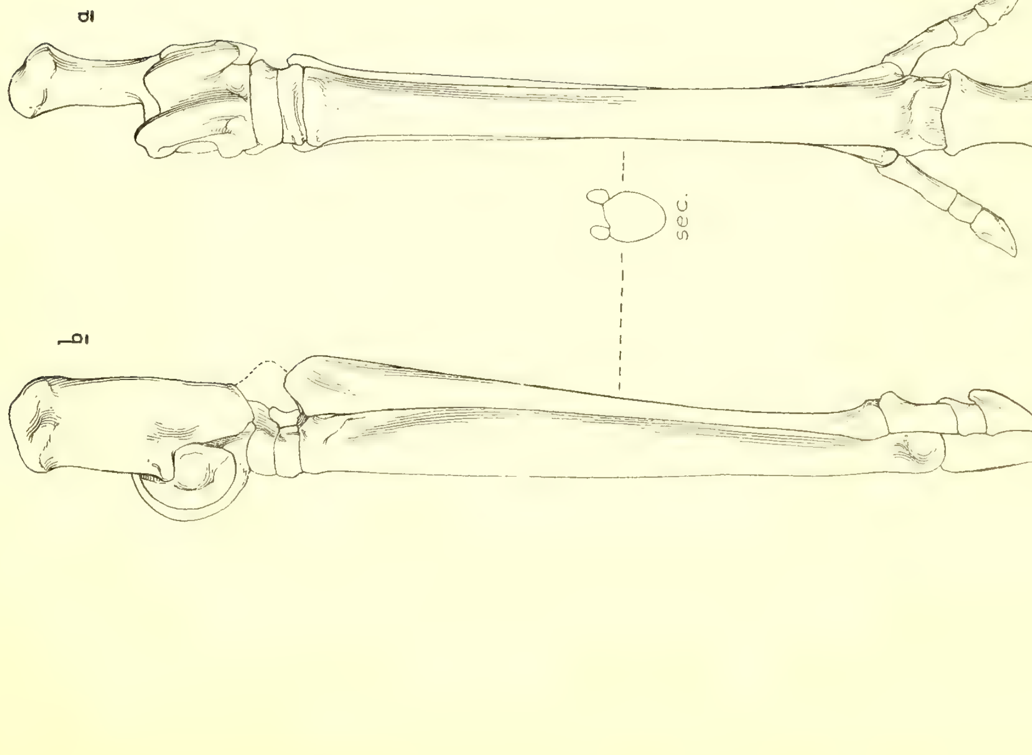
HIND FEET OF *MERYCHIPPUS ISONESUS SECUNDUS, M. I. TERTIUS, M. I. QUARTUS.*

COMPARISON OF PES IN THREE SPECIES FROM THE SHEEP CREEK BEDS OF NEBRASKA.

All figures one-half natural size.

Sheep Creek, Nebr.	Middle Miocene	1. *Merychippus isonesus secundus* Osborn, type, Am. Mus. 14179. Associated with fragments of jaw, teeth, and parts of skeleton. *a*, Anterior, *b*, external view.
" " "	" "	2. *M. isonesus tertius* Osborn, type, Am. Mus. 14180. Associated with skeleton. Anterior view.
" " "	" "	3. *M. isonesus quartus* Osborn, type, Am. Mus. 14184 (reversed in drawing), *a*, anterior, *b*, external view. Associated with other skeletal parts, lacking skull and teeth.

1

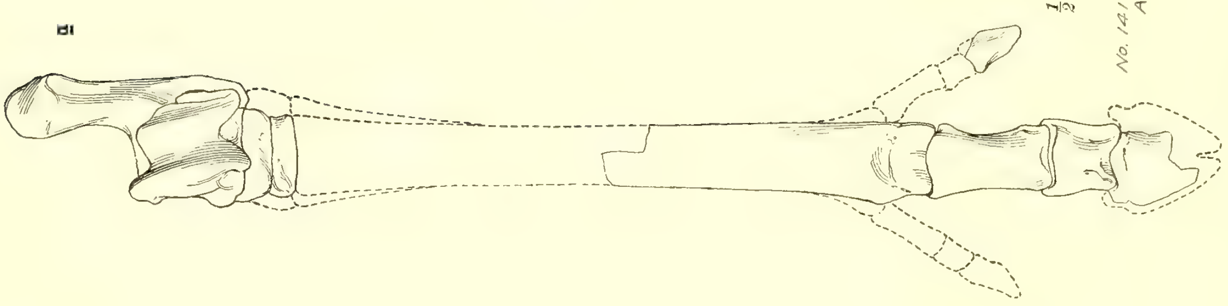


1/2

No. 14179 Type
A. M.

Merychippus isonesus secundus

2

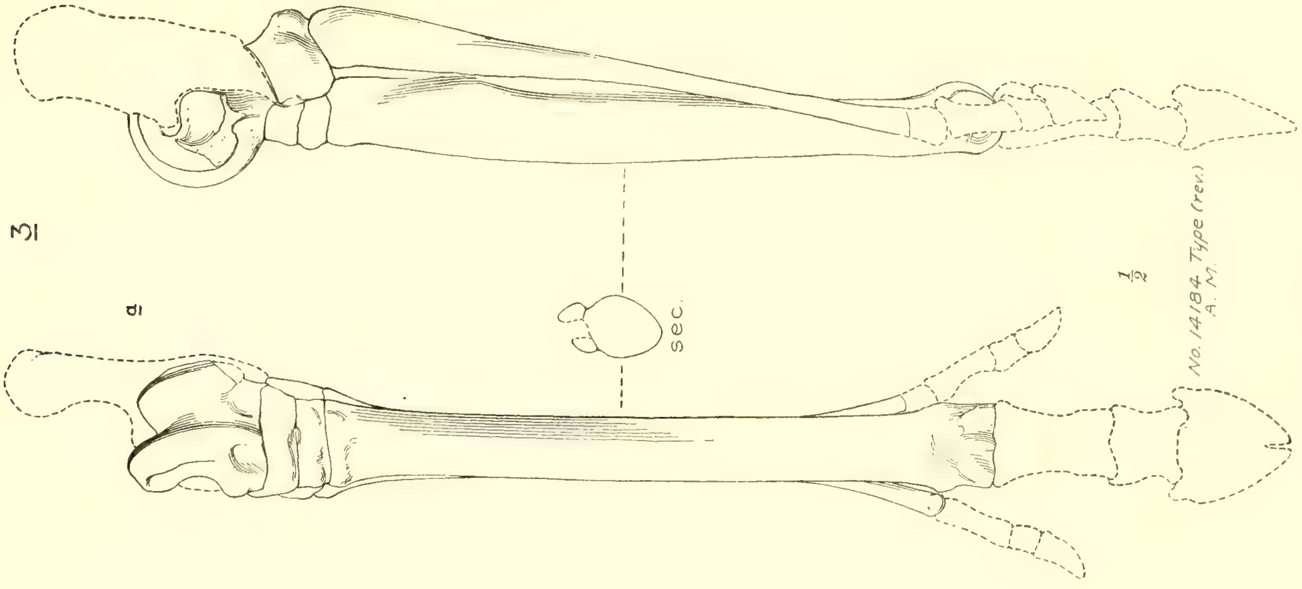


1/2

No. 14180 Type
A. M.

M. isonesus tertius

3



1/2

No. 14184 Type (rev.)
A. M.

M. isonesus quartus

PLATE 53.

HIND FEET, *MERYCHIPPUS.*

PLATE 53.

HIND FEET OF *MERYCHIPPUS SPHENODUS, M. PANIENSIS, M. SEJUNCTUS.*

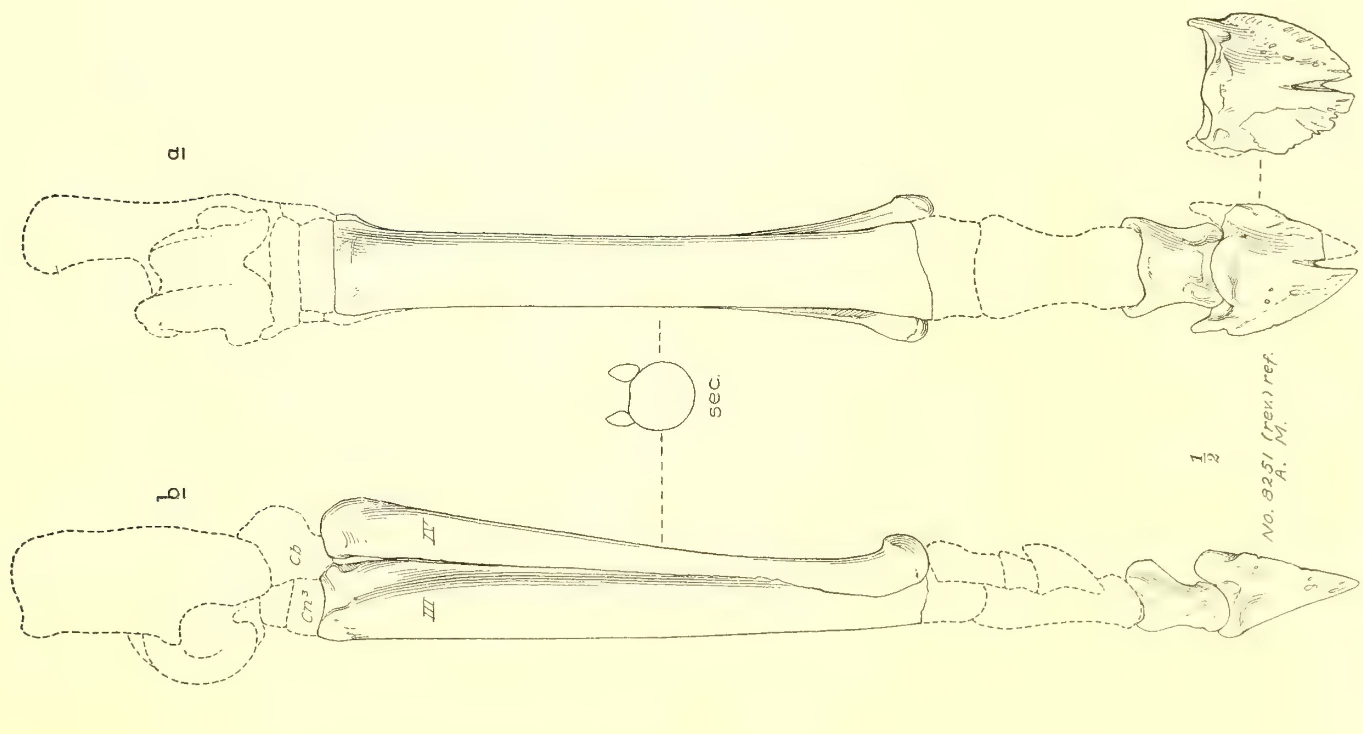
EXTERNAL AND ANTERIOR VIEWS OF PES IN THREE COPE SPECIES FROM THE PAWNEE CREEK BEDS OF NORTHEASTERN COLORADO.

All figures one-half natural size.

Compare with other species from the same beds, shown in Plate 54.

Pawnee Creek, Col.	Middle Miocene	1. *Merychippus sphenodus* Cope, referred specimen, Am. Mus. 8251 (reversed in drawing). Associated with teeth and part of skeleton. Metatarsus and phalanges of pes, *a*, anterior and, *b*, external view; *c*, anterior view of ungual phalanx of fore foot.
" " "	" "	2. *M. paniensis* Cope, referred specimen, Am. Mus. 9382. Associated with skull, jaws, and large part of skeleton. *a*, Anterior, *b*, external view.
" " "	" "	3. *M. sejunctus* Cope, type, Am. Mus. 8291 (reversed in drawing). Associated with skull, jaws, and part of skeleton. *a*, Anterior, *b*, external view.

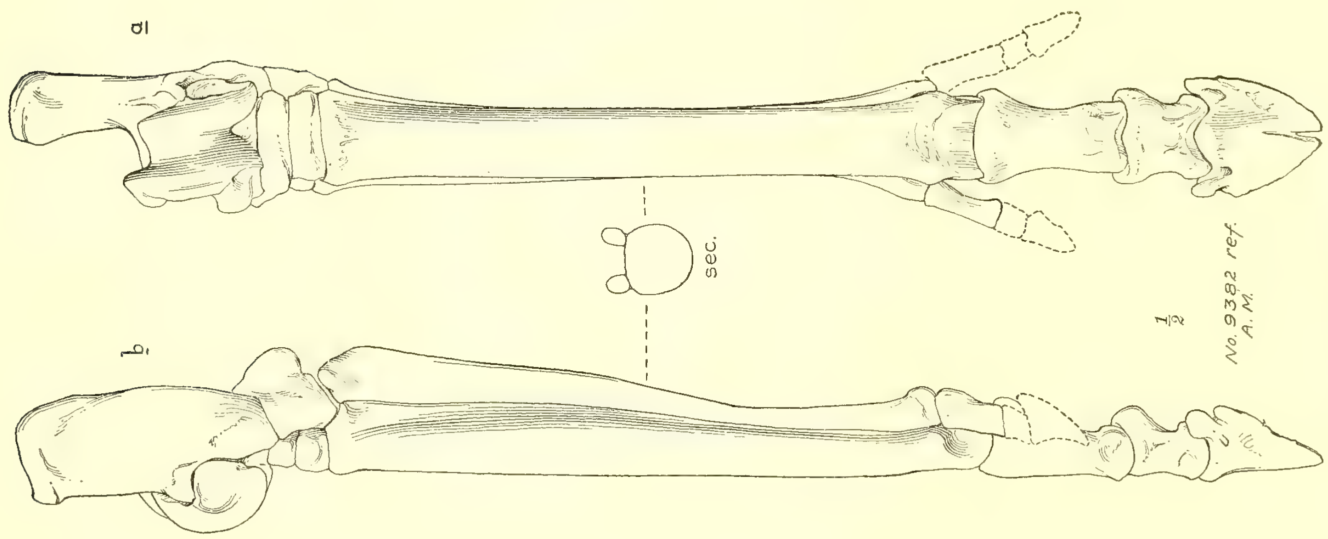
1



Merychippus sphenodus

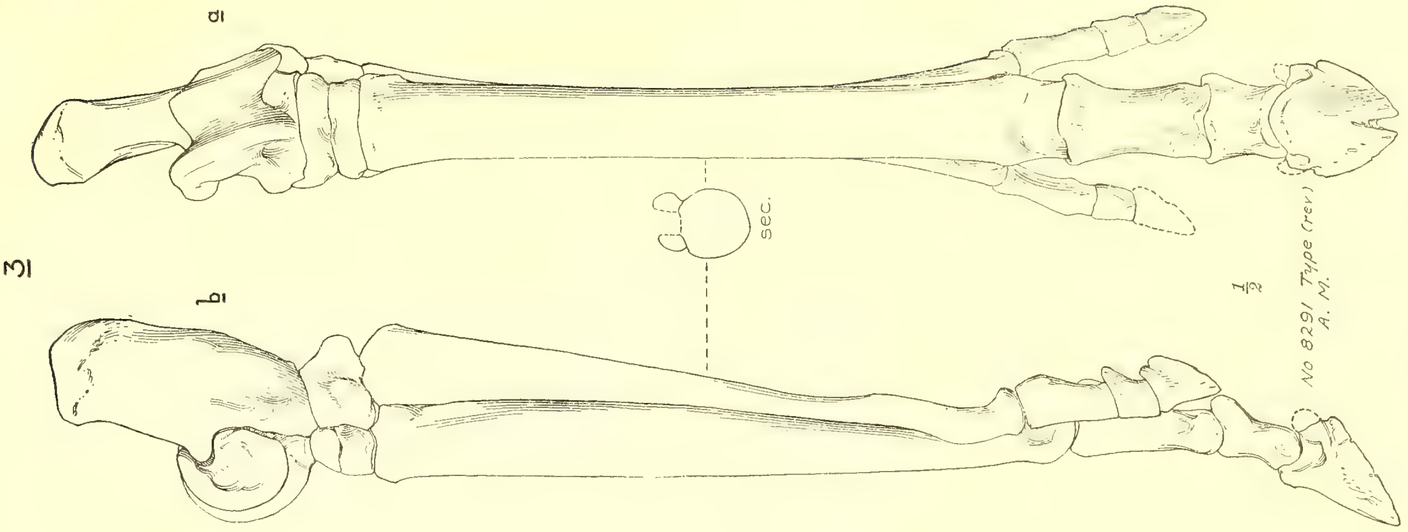
L.M.S.

2



Merychippus paniensis

3



Merychippus sejunctus

PLATE 54.

HIND FEET, *MERYCHIPPUS.*

PLATE 54.

HIND FEET OF *MERYCHIPPUS PROPARVULUS, EOPLACIDUS, EOHIPPARION.*

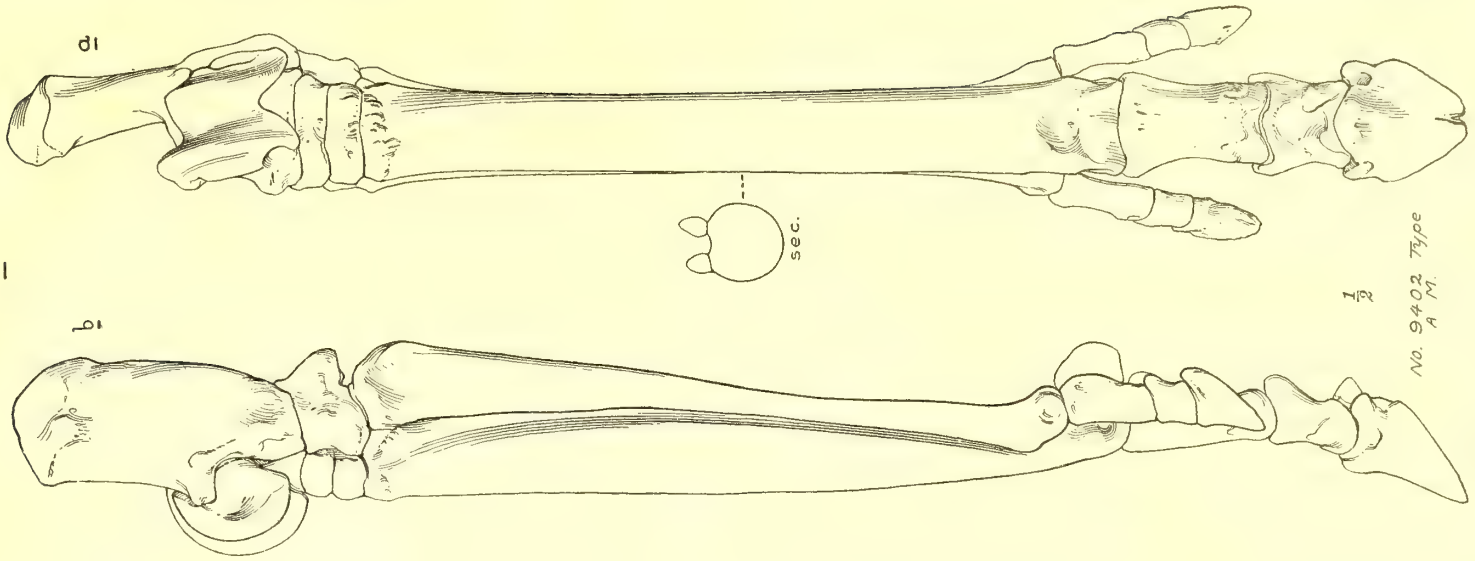
ANTERIOR AND EXTERNAL VIEWS OF PES IN THREE SPECIES FROM THE PAWNEE CREEK BEDS OF NORTHEASTERN COLORADO.

All figures one-half natural size.

Compare with other species from the same beds, shown in Plate 53. The lateral digits are much reduced and the cannon bone is slender in *Merychippus eoplacidus.*

Pawnee Creek, Col.	Middle Miocene	1. *Merychippus proparvulus* Osborn, type, Am. Mus. 9394. Associated with upper jaw and part of skeleton. *a,* Anterior, *b,* external view.
" " "	" "	2. *M. eoplacidus* Osborn, type, Am. Mus. 9397 (reversed in drawing). Associated with lower jaws and part of skeleton. Same views as 1.
" " "	" "	3. *M. eohipparion* Osborn, type, Am. Mus. 9402. Associated with lower jaws and greater part of skeleton. Same views as 1.

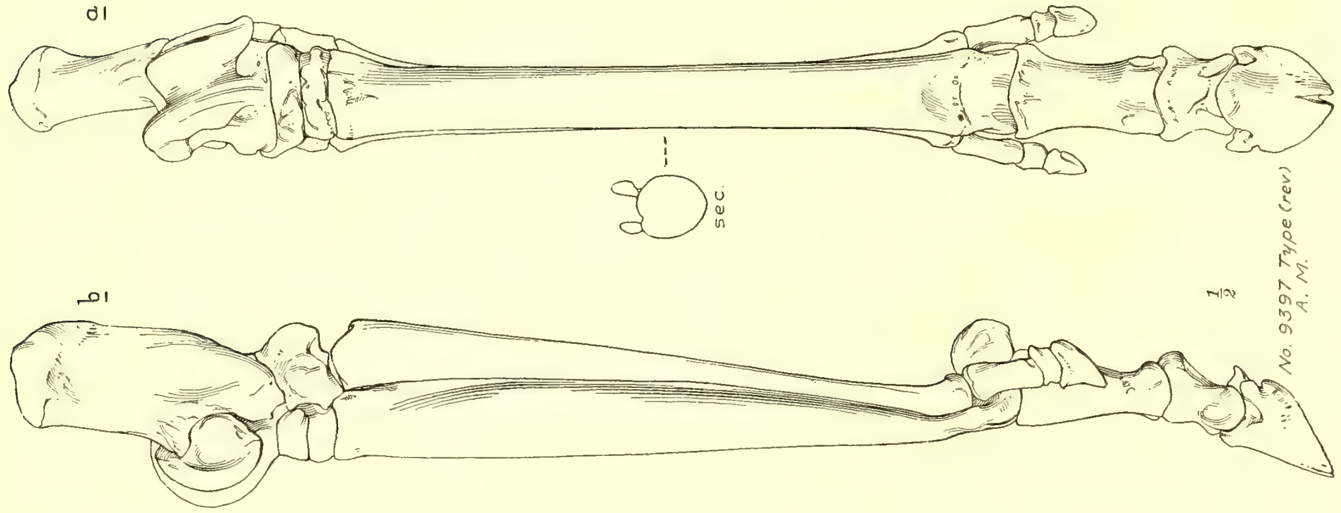
3



1/2 No. 9402 Type A. M.

Merychippus eohipparion

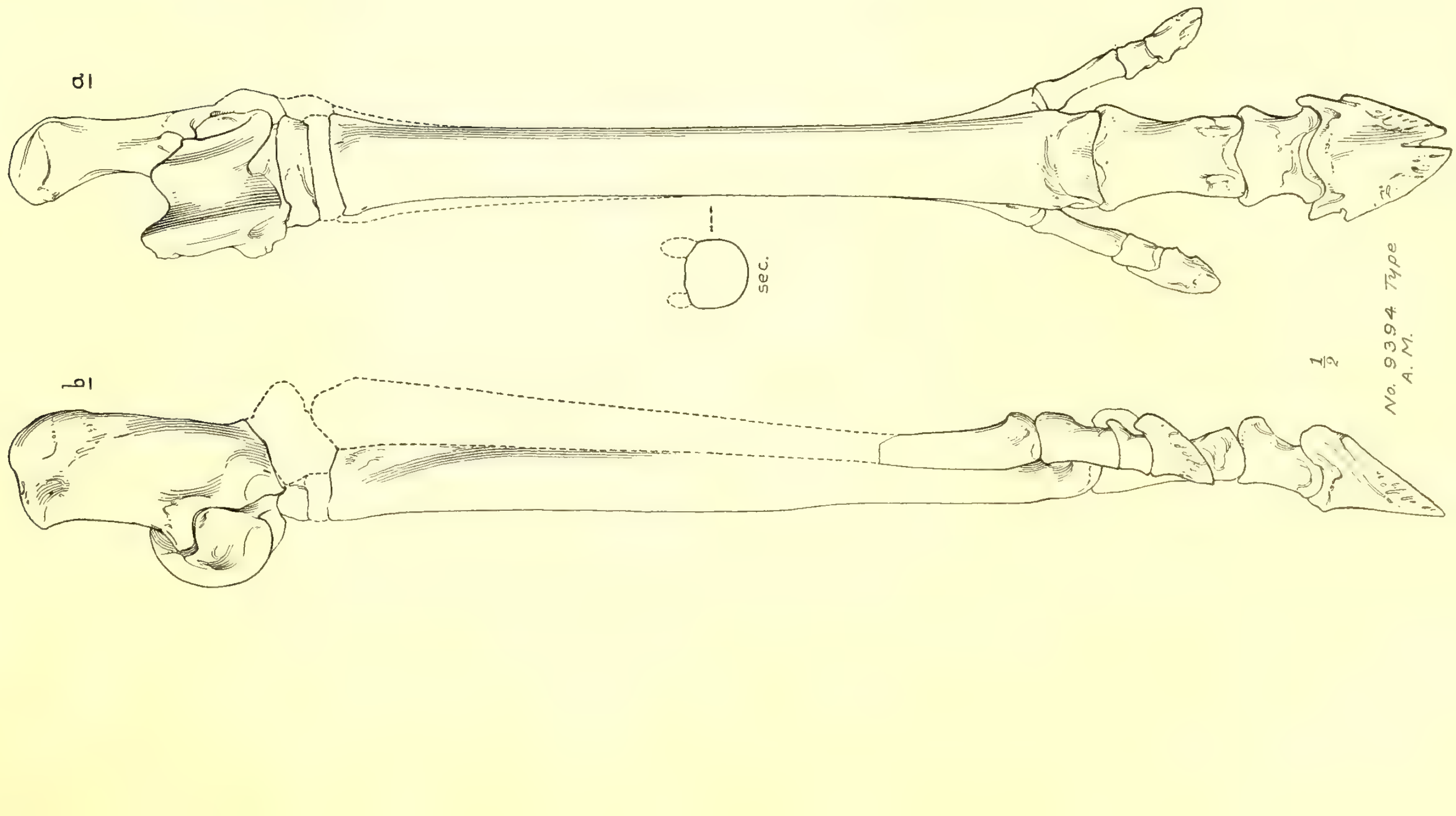
2



1/2 No. 9397 Type (rev.) A. M.

Merychippus eoplacidus

1



1/2 No. 9394 Type A. M.

Merychippus proparvulus

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